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MASTER’S THESIS

The Effects of Geopolitics on Commodity Prices

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Abstract

The thesis examines the effects of geopolitical events on global crude oil, wheat and aluminum prices. Geopolitical events have the potential to disrupt the production and supply of commodities to markets, affecting prices. Path analysis models that mirror crude oil, wheat and aluminum markets are constructed using theories specific to each commodity to measure how substantial the impacts of different variables are upon prices. Vector error correction models are then employed to test if individual geopolitical events have long-term effects on prices. An analysis of production and exports of commodities in regions and countries affected by geopolitical events is conducted to determine how severely production is disrupted. A basic examination of prices before, during and after geopolitical events is conducted to understand how quickly drivers of commodity prices can shift between geopolitical events and supply and demand fundamentals. It also serves to show how quickly prices revert to pre-event levels following a geopolitical event.

JEL Classification

C22, Q34, Q41, R32

Keywords

Commodities, Geopolitical Events, Prices, Crude Oil, Wheat, Aluminum

Range of Thesis: 130,482 symbols. 67 pages.

Abstrakt

Práce zkoumá účinky geopolitických událostí na globálních ropy, pšenice a hliníkových ceny. Geopolitické události mají potenciál narušit výrobu a dodávku zboží na trhy, které ovlivňují ceny. Analýza cesta modely, které odrážejí ropy, pšenice a hliníkových trhy jsou konstruovány s využitím teorií specifické pro každou komoditu změřit, jak podstatné dopady různých proměnných jsou na ceny. Vector chybové korekce modely jsou pak použity k otestování, zda jednotlivé geopolitické události mají dlouhodobý vliv na ceny. Analýza výroby a vývozu komodit v regionech a zemích postižených geopolitické události se provádí určit, jak vážně výroba je narušena. Základní vyšetření cen před, během a po geopolitických událostí je vedena porozumět tomu, jak rychle se řidiči cen komodit lze přepínat mezi geopolitických událostí a dodávek a základy poptávky. Slouží také ukázat, jak rychle se ceny vrátí hladiny pre-událostí následující geopolitické události.

Klasifikace JEL

C22, Q34, Q41, R32

Klíčová slova

Komodity, geopolitické události, Ceny, ropa, pšenice, hliníkové

Declaration of Authorship

1. The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

2. The author hereby declares that all the sources and literature used have been properly cited.

3. The author hereby declares that the thesis has not been used to obtain a different or the same degree.

Prague … 23 July 2016 Robert T. McGrouther

Master Thesis Proposal

Institute of Political Studies
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Proposed Topic:

The Effects of Geopolitics on Commodity Prices

Registered in SIS: Yes Date of registration: 19.06.2015

Topic Characteristics:
The topic of my thesis will center on the inability of geopolitical events in the modern global economy to influence relevant global commodity prices in the long-term. Geopolitical events are often credited with changing the economic and financial environment of states, regions, and global markets. Examples include the 2003 invasion of Iraq effecting oil prices and more recently Russian aggression in Georgia and Ukraine that is associated with both oil and agriculture commodity prices. However, I believe that immediate commodity price changes created by geopolitics are overreactions, and that prices will move back towards pre-event levels in the short-run, although unrelated factors may lead to price increases during that time. Specifically, I will argue that permanent rises in commodity prices during a time period corresponding to a geopolitical event are the result of demand outpacing production, the policies of relevant states, and speculation, not shocks created by geopolitical events. Furthermore, globalization has allowed markets to more effectively respond to shocks, reducing their long-term impact. Even during hardship brought about by geopolitical events, producers maintain output, although not all of it may be supplied to market. If one producer or region cannot meet demand or maintain output, others will increase production, stabilizing supply.

Working hypotheses:
1. Geopolitical events do not have substantial impacts on commodity prices.
2. Immediate changes of commodity prices following geopolitical events are often overreactions, and prices will return to reasonably similar levels in the short run.
3. Long-term price rises that would appear to be the result of shocks caused by geopolitical events are in fact the result of demand outpacing production or market authorities controlling supply.
4. Producers within the vicinity of geopolitical events will continue to provide output; the market will adjust to changing conditions if this is not the case.

Methodology:
To determine the (lack of) effects of geopolitical events on commodity prices, I will create path analysis models for three different commodities. Testing the second hypothesis will include vector error correction models that test whether the geopolitical events have long term impacts on commodity prices. The third hypothesis can be tested through examining commodity prices, demand, and production levels, particularly during time periods surrounding geopolitical events. The fourth hypotheses will be examined

through a consultation of data related to specific markets and producers directly exposed to geopolitical events. If local production is indeed affected beyond the short run by an event, I will attempt to find evidence of global market suppliers adjusting to such changes, and the effect on commodity prices.

Outline:

1. Introduction
2. Theory regarding subject and breadth of current knowledge
3. Path Analysis Models of Geopolitical Events Impact on Commodity Prices
    a. Methodology
    b. Results
4. Vector Error Correction Models
    a. Methodology
    b. Results
5. Disruption of Local Production
    a. Effects on Output
6. Conclusions
7. References/Bibliography
8. Model Outputs

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Table of Contents

1. Introduction

Commodities drive the global economy, and are the inputs required to produce the infrastructure and consumer goods individuals rely upon every day. In the modern globalized economy, commodities extracted from the earth in one country are often processed and sold in numerous different countries across the world. The system of trade involving producers, consumers, exports and imports that the global economy is comprised of and the state level economies that interact within it are constantly evolving, with ever-changing markets correcting for shocks and adjusting prices accordingly. It is through commodity prices that a balance is maintained in the global economy. An increase in primary commodity prices leads to an increase downstream in the price of goods purchased by consumers and industry. Such price fluctuations can produce immense consequences for economies reliant upon a specific commodity, depending on whether they are a major exporter or importer of that commodity.

This paper focuses on the actors and dynamics of global crude oil, wheat and aluminum commodity markets. Specifically, this paper will investigate the effects of geopolitical events on the prices of these commodities. The models presented in this paper are not intended to possess predictive properties; they were created with the sole intention of measuring the effects of geopolitical events and other relevant variables upon commodity prices.

Despite a vast collection of literature concerned with primary commodity prices, there is a near absolute lack of research directly related to geopolitical events' impact on commodity prices. Works exist with models that include geopolitical events, however these events are meant to represent shocks in commodity markets, their effects never being fully measured to demonstrate their importance in commodity prices. Previous research on commodity markets are still of much use in this paper, forming the underlying economic theories that the models in this paper are based upon.

Presented in this work are four hypotheses related to commodity prices. First, geopolitical events do not have substantial impacts on commodity prices in the modern global economy. Second, immediate changes in commodity prices as a result of geopolitical events are often overreactions, and prices will revert to appropriate levels in the short run. Third, long-term price rises that would appear to be the result of geopolitical events are in fact the result of demand and supply variables unrelated to geopolitical events. Fourth, producers within the vicinity of geopolitical events will continue to provide output; other producers in the market will adjust to compensate if this is not the case.

The paper will be presented in eight parts, beginning with Part One, this introduction. Part Two, “Theory Review” will cover the economic theory regarding commodity markets, most of which is provided by previous research conducted by individuals specializing in a variety of fields. While theories provided by others will be mentioned throughout the paper, Part Two will serve as a literature review. Part Three, “Path Analysis Models” will provide separate path analysis models for crude oil, wheat and aluminum markets. These path analysis models measure the effects of variables upon each other, providing the data output required to test the first and third hypotheses. A theoretical explanation of the data and methodologies used will be included. Part Four, “Vector Error Correction Models” will measure whether or not geopolitical events have long-term effects on commodity prices. These models will act as tests for the third hypothesis, and will also include theoretical explanations for the data and methodologies used. Part Five, “Local Effects of Geopolitical Events” will test the second and fourth hypotheses through basic methods, using deductive reasoning and numerical data to determine the effects of geopolitical events on local producers, and the global markets’ reactions. Part Six “Conclusion” will contain a review of the results and draw conclusions. Part Seven will include the bibliography, and Part Eight will provide an appendix of model results.

2. Theory Review

2.1 Crude Oil

When discussing the economic theory of commodity prices, we shall begin with the most basic variable, economic activity. If economic activity decreases across developed economies, producers experiencing or expecting drops in demand will often lower output to maintain profitability during times of decreasing or stagnant economic growth; exceptions to this phenomenon will be discussed later in this section. However, depending on the elasticity of demand for a specific commodity, producers may keep output high, particularly if the commodity is non-perishable and can be stored (Pirrong 2009, p. 2). This decision will be based on whether it is profitable to store a commodity. If a producer expects prices to rise in the future to levels that would be profitable, meaning the future price of the commodity is greater than the current cost of both extraction and storage until the price rise, then producers will choose to maintain output (Pirrong 2009, p. 2) If a producer views an economic downturn as a long-term phenomenon, wholly unsure of when or if prices will rise in the future to levels that would make storage of a commodity a profitable venture, they will cut production. (Pirrong 2009, p. 2) In the case of crude oil, the infrastructure for storing oil is well developed, allowing for the accumulation of massive stockpiles, even during extended periods of low prices. This is occurring at the moment across the world, as oil producing states report record-breaking stockpiles of crude oil, despite a long-term drop in prices to the lowest levels in years.

Production cuts by major oil producers were evident, although not substantial, as a result of the Asian financial crisis of 1997, the recession during the early 2000's spanning Europe and the US, and the global financial crisis of 2007-2008 (EIA). Oil producers and governments reduced the number of active rigs and producing wells, but more importantly also decreased investment in completing wells and refinery capacity (OPEC Table 3.2, Table 3.4) These actions were the result of drops in demand for crude oil, a consequence of negative GDP growth during 1997-1998, 2001 and 2009 (IEA; World Bank). During the interval periods between these economic downturns, oil-producing states would reactivate rigs and producing wells, while once again funding the completion of more wells and refinery capacity (OPEC Table 3.2, Table 3.4). These reactions were not typically instantaneous; lags were present, indicating that a period of months passes before decisions to reduce output are implemented. Decisions to increase production and investment appear to occur much more quickly following improvements in global markets (OPEC).

The Organization of the Petroleum Exporting Countries (OPEC) produces the approximately 40% of the world's crude oil (OPEC Table 3.6). OPEC's target allocation quotas for individual member states are an effective indicator for understanding the lags existing in the current crude oil market. King *et al.* (2011) proves that oil prices respond to changes in OPEC quotas, confirming that increases in OPEC quotas lead to lower crude oil prices, and announcements declaring a drop in OPEC quotas leads to higher crude oil prices. As an organization that controls more of the world's crude oil production than any single state, OPEC has the ability to influence crude oil prices in ways that no single state can (Chevillon & Rifflart 2009 p. 538). Due to the fact the OPEC economies are reliant on crude oil production, they often cheat on their quotas, and Saudi Arabia is forced to reduce its own production to maintain prices (Zycher 1993). Sometimes the organization as a whole agrees to continue production, even when the price of crude is low, demand is low, and their actions only drive crude prices lower (OPEC Table 1.2) These actions will be investigated further in Part Five, when examining the effects of different variables upon local production and the global market responses.

Demand for crude is relatively inelastic, with reductions in demand never matching the magnitude of a financial crisis that may affect commodities (Dees et al. 2008, p. 12; IEA). During the Asian financial crisis of 1997 and the recession during the early 2000's, demand for crude oil continued to grow, albeit at much lower levels, even when global GDP was experiencing negative growth (IEA). It wasn't until 2008 during the global financial crisis that negative GDP growth also resulted in negative growth for crude oil demand (World Bank; IEA). Where demand and supply for crude oil intersect is stockpiles. When production is high and demand is low, stockpiles grow. When production is low and demand is high (these periods are brief, production typically adjusts quickly to increased demand), stockpiles are depleted. This theory is confirmed by King *et al.* (2011) when he tested OECD stocks, concluding that a drop in crude oil prices quickly follows growing stocks. However, crude oil prices can rise temporarily during increases in stocks due to shocks or if refinery capacity utilization is at a high level during periods of economic prosperity (Pesenti & Groen 2011, p. 4). Increased production and refinery capacity requires investments to have been committed years prior, and take years to develop (Chevillon & Rifflart 2009, p. 547; King et al. 2011, p. 12) As a result, prices can rise during stretches of economic growth due to constraints on refinery capacity (Pesenti & Groen 2011, p. 4) Such a scenario is responsible for the price increases of 2004 according to Chevillon and Rifflart (2009) who cites Kaufmann, and during 2007 and 2008 (Kaufmann et al. 2008, p. 2618; Pesenti & Groen 2011, p. 4) Investments in refinery capacity suffered in the late 1990's and early 2000's from the Asian financial crisis and recession in Europe and the US, leaving the market unable to cope with large increases in production to meet growing demand (EIA; King et al. 2011, p. 13). During these periods production of crude is typically high, but production and refinery capacity can't meet increased levels of demand, and so stockpiles of crude oil not yet refined and crude oil prices increase simultaneously. However, when production is meeting demand, increases in refinery utilization rates drive prices down (Dees et al 2008, p. 17). Stocks and prices can also increase simultaneously during times of greater volatility as stocks are built up as precautions to soften the blow of shocks (Pirrong 2009, p. 4).

As stockpiles are depleted, prices tend to increase (Dees et al., 2008). This is the result of demand outpacing production and leads to speculation of a supply shortage. The global financial crisis was beginning to take form during the price increase caused by a lack of refinery capacity. In late 2008 and early 2009 when the economic effects of the global financial crisis were being felt around the world, the price of crude oil decreased (IMF). This was the result of producers not cutting output by substantial amounts while demand plummeted (EIA; IEA). During periods of financial crises, stockpiles tend to increase, and prices will decrease by varying amounts depending on the extent to which producers choose to reduce production and how much demand is reduced (Pirrong 2009, p. 4; Bernard et al. 2006, p. 1). During the Asian financial crisis of 1997 and the recession across Europe and the US during the early 2000's, prices decreased as producers did not reduce output by substantial levels and demand growth remained positive at much lower levels, leading to increased stockpiles (EIA). The resulting price decrease from the global financial crisis occurring for several months in late 2008 and early 2009 was stymied by OPEC, which cut production to prevent oil prices from falling further ("OPEC Annual Report 2009" 2009, p. i). However, OPEC member states are still dependent on crude oil revenues, and their production cuts were not too substantial (OPEC).

Government financial and economic policies are also responsible for movements in prices. Interest rates and currency exchange rates are crucial variables when analyzing commodity markets. Governments will lower interest rates during times of economic hardship in an attempt to increase borrowing, and in turn economic growth (Mishkin 2010). Increases in interest rates often lead to appreciations in the domestic currency (Levi 2005, p. 473). When the US government raises interest rates, the dollar becomes stronger, and when interest rates are low, the dollar tends to weaken (Levi 2005, p. 473). The Federal Funds Rate and Treasury Bill Rate set by the US Federal Reserve have a positive correlation with the US dollar (Bonser et al. 1998, p. 148). The dollar has a negative correlation with oil prices, and so by default US interest rates have negative correlations with oil prices (Grisse 2010, p. 2). When interest rates rise, the value of dollar increases, and in turn oil prices decrease.

The final element essential to an analysis of the crude oil market is geopolitical events. Geopolitics is defined as "a combination of political or geographic factors relating to something (as a state or particular resource)" ("Geopolitics"). Therefore, geopolitical events are conflicts between or within states. For the analysis on crude oil, the Iraq War, the Russo-Georgian War, the Arab Spring will serve as geopolitical events. Each of these events involves hostilities between two or more governments, secessionist groups, or insurgent groups, and meets the criteria for a geopolitical event.

The effects of geopolitical events on commodity markets are numerous, and dependent on the state of the market at the time hostilities begin. Speculation on whether a geopolitical event will take place can affect the market before it even begins, with producers and consumers preparing for its effects (Chevillon & Rifflart 2009, p. 547). Speculation on geopolitical events theoretically can drive up prices in the months and weeks preceding an initiation of hostilities, as may have been the case of the Iraq War in 2003 (Chevillon & Rifflart 2009, p. 547). Geopolitical events are difficult to predict and their duration is unknown, causing increased volatility in markets. As a result of speculation and expected increases in volatility caused by geopolitical events, stockpiles will increase to offset any interruptions in supply (Pesenti & Groen 2011, p. 5). Geopolitical events fall under the previously mentioned category of shocks that can cause stockpiles and prices to rise together. OPEC is a crucial player when stabilizing crude oil markets in times of increased speculation and volatility, not only because of its role as a powerful cartel, but also due the geographic location of the majority of its member states. Most OPEC member states are located in the Middle East and North Africa, conflict prone regions for much of modern times. The Iraq War and Arab Spring both involve OPEC member states; the Arab Spring in particular directly affects both Iraq and Libya. Other member states are themselves quite unstable politically, including Venezuela, Nigeria, and Iran (King et al. 2011, p. 2, 14). OPEC is adept at foreseeing geopolitical conflict and shifting its quotas for member states to avoid any serious underperformance in supply to the world market (King et al. 2011, p. 1).

In some cases, production in a state is completely unhindered by a geopolitical event occurring within its borders. This was the case of Kuwait in 1990 during the first Gulf War, and is the case of Iraq currently, where the Islamic State has wrested large regions of land from government control (Kaufmann et al. 2004, p. 78; OPEC Table 3.6). The Iraqi government and Kurdish forces still control nearly all of the oil fields in Iraq, and production has reached pre-Iraq War levels (OPEC Table 3.6). As pointed out by Kauffmann (2004, p. 78), in the months following the start of the Gulf War, crude oil prices rose as the market expected supply from Kuwait to become limited. However, it quickly became understood that the war would have no effect on crude oil supplies from the region, and by the start of 1991 crude oil prices had returned to pre-event levels (Kaufmann et al. 2004, p. 78). Crude oil prices have began to slide in mid-2014 despite Islamic State controlling large swaths of Iraq, Libyan production currently operating at levels only a fraction what it supplied to market before the Arab Spring, and Russia invading Ukraine in February of 2014 (IMF). None of these events have managed to create large disruptions in the global production of oil. This is in part due to OPEC acting as some form of an insurance policy against geopolitical events, and the US increasing production in recent years to become more energy independent (OPEC). As the world market develops further, it becomes less susceptible to price increases caused by geopolitical events and resulting speculation and volatility.

Some of the actors involved in current and past geopolitical events have only ever played the role of aggressors. This is case with both the United States and Russia as of late. The largest and third largest producers of oil, respectively, their supply of crude to market is never physically threatened (EIA). Russia, however, supplies much of Europe's oil and gas, and Europe is aware of Russia's ability to limit supply in response to possible sanctions that could have been imposed as reactions to Russia's actions in Georgia (Newnham 2011, p. 137). This fuels speculation, and in turn increases volatility and crude oil prices. These price increases are never long lasting though, simply overreactions that subside as production continues, even if some states must increase output to compensate for other states affected by geopolitical events.

One of the last topics concerning the prices of crude oil is the futures market. Researchers attempting to forecast primary commodity prices have long tried to understand the role that futures have on primary commodity prices. Reputable researchers have concluded that there is a disconnect between futures assets and primary prices. Whether the futures market is in contango or backwardation has no effect on the real prices of primary commodities, and is only of concern to speculators in futures markets (King et al. 2011, p. 3). While both markets are influenced by many of the same variables, financial assets do not affect primary commodity prices, and so they will not be discussed further in the paper (King et al. 2011, p. 52).

The economic theory reviewed in this section show that supply and demand fundamentals coupled with the economic policies of governments are responsible for long-term changes in commodity prices. Geopolitical events of recent decades may certainly be responsible for short-term price fluctuations, but their effects are not long lived, as they have not occurred on large enough scales to significantly disrupt global supply. This supports the hypotheses, and the theory presented will be used to construct the models used to test the hypotheses in the following sections.

2.2 Wheat

Wheat is an essential food commodity that is planted around the world, using more land than any other agricultural commodity for its growth (Janzen et al. 2014, p. 2). Wheat is used both for human consumption and as feed for livestock. The global wheat markets shares some fundamental variables with crude oil and other commodities, but also involves factors that are unique to agricultural commodities (Janzen et al. 2014, p. 1). The same as any other good, wheat prices typically rise with lowered production, increased demand, and shrinking stockpiles (GEM; IAI). Wheat prices tend to drop with increased production, lower demand and growing stockpiles (GEM; IAI). Wheat shares the same storage dynamic as crude oil since it is a storable commodity. Wheat and other agricultural commodities are influenced by weather patterns more severely than other commodities (Janzen et al. 2014, p. 4). Different regions of the world have different planting, growth, and harvesting seasons, as do different types of wheat. Too much precipitation or not enough precipitation can adversely affect wheat yields, and in turn affect wheat prices. In research conducted by the United States Department of Agriculture, it was found that the main cause of spikes in wheat prices between 1991 and 2011 in the US wheat markets was due to shocks that only affect agricultural commodities (Janzen et al. 2014, p. iv). The researchers determined that during the February 2008 wheat price spike, prices were supposed to have been 40-60% percent lower if adverse weather had not affected wheat yields (Janzen et al. 2014, p. iv). Similar to other commodities, there wasn't just a supply shock. Speculators created a demand shock by increasing stockpiles of wheat as a result of predicted lowered wheat yields that would affect prices (Janzen et al. 2014, p. v). Shocks related to changes in global economic activity were found to have only a 9-12% effect on prices in February 2008 (Janzen et al. 2014, p. v). Similar to the crude oil market, financial market speculation and futures trading had little to no impact on wheat prices during the price spike, being responsible for at most only a 1% change in prices (Janzen et al. 2014, p. v). This shows that wheat prices are influenced by fundamental variables, and that futures markets do not affect spot wheat prices.

It is important to understand how wheat prices are affected by economic activity, as they are unique from crude oil and aluminum markets, but closely intertwined.

Increased economic growth, particularly in developing countries, leads to higher demand for commodities and increases their prices (Janzen et al. 2014, p. 3). Energy and industrial commodities including metals are directly affected by economic growth. Increased prices for energy commodities lead to higher production costs for agricultural producers and increased costs for transporting agricultural goods (Janzen et al. 2014, p. 3). In addition, economic growth creates higher incomes, allowing consumers greater access to different goods and increasing their demand (Janzen et al. 2014, p. 3). Specifically, developing countries with growing incomes begin to consume more meat and fewer grains (Janzen et al. 2014, p. 3). Wheat's role as a good consumed by humans is altered, instead being used to feed livestock consumed in greater portions as incomes rise. To produce one pound of meat requires feeding the livestock large quantities of grain, including wheat (Janzen et al. 2014, p. 3). This leads to large increases in demand for wheat, which raises its price (Janzen et al. 2014, p. 3). Researchers state that massive developing countries such as China and India with rapidly growing demand for wheat and meat are now fundamental actors in the fluctuations of the price of wheat (Janzen et al. 2014, p. 3). The percentage of a wheat yield that is fed to livestock also depends on the quality of the wheat, with lower quality wheat being fed to livestock (Janzen et al. 2014, p. 6). How much wheat is used for feed is also influenced by the price of other crops used for livestock feed, including corn (Janzen et al. 2014, p. 6). During periods of good wheat quality and high prices, almost no wheat is used for livestock feed, which is what happened in 2007 and 2008 (Janzen et al. 2014, p. 7). In early 2011 however, even with high wheat prices, lower quality wheat was used for livestock feed purposes (Janzen et al. 2014, p. 7).

There are other variables to consider when building a comprehensive understanding of the influences on wheat prices. Low interest rates make it more affordable to store wheat, which allows producers to keep wheat from entering markets (Janzen et al. 2014, p. 3). While growing stockpiles tend to drive prices down due to reduced fear of shortages, producers can also stockpile wheat to the point that not enough wheat is entering the market, driving wheat prices up as a result (Janzen et al. 2014, p. 3). They can then move the wheat to market and temporarily sell it for a greater profit. It is also worth noting that the elasticity of wheat prices is greater than for retail goods, and so wheat prices can overreact to monetary shocks such as changes in interest rates (Janzen et al. 2014, p. 3).

Wheat shares supply and demand factors with other agricultural commodities. Supply shocks are the main driver of short-run changes in wheat prices (Janzen et al. 2014, p. 3). Once wheat is planted, supply is often very inelastic, and so shocks to supply change prices (Janzen et al. 2014, p. 3). Production of wheat is dependent on the acreage planted and the amount of wheat that is yielded by the acreage (Janzen et al. 2014, p. 3). More developed countries have higher yields per acre than less developed countries as a result of more advanced agricultural technology. Increases in wheat production around the world are not the result of greater acreage of planted wheat, but increased yields from those acres (Janzen et al. 2014, p. 3). Since 1960, acreage has increased at 0.04 percent annually, but yields have grown at nearly 2 percent each year (Janzen et al. 2014, p. 4). Long-run factors that influence wheat production are predictable, and so any volatility in wheat prices is caused by short-run variables that affect production. Although El Nino and La Nina do not occur at regular frequencies or for set periods of time, their effects are predictable months before they begin; however, other immediate weather effects as well as disease and pests are difficult to foresee and can negatively impact wheat yields and cause supply shocks, affecting price (Janzen et al. 2014, p. 4).

The main producers of wheat are the US, European Union, China, Russia, Kazakhstan, Ukraine, India, Argentina, Pakistan, Canada, and Australia (Janzen et al. 2014, p.5). Between 2002 and 2011, they produced more than 84 percent of the world's wheat (Janzen et al. 2014, p. 5). Globally, almost no wheat is harvested in January or February, but in every other month of the year wheat is being harvested (Janzen et al. 2014, p. 5). India starts to harvest in March and the US and EU typically begins to harvest winter wheat in May (Janzen 2014, p. 5). The winter wheat harvest continues until the spring wheat harvest in the US and Canada that starts in July and runs through October (Janzen et al. 2014, p. 5). Producers in the Southern Hemisphere, Argentina and Australia, conduct their harvest in November and December and in late spring and early summer, depending on the strain of wheat (Janzen et al. 2014, p. 5). As a result of global producers harvesting nearly year round, there is very little seasonal changes in the price of wheat (Janzen et al. 2014, p. 5).

Supply disruption will affect prices more if the disruption happens in a country that exports wheat to countries that require imports to meet demand. Trade controls are one of the factors that can reduce exports and imports, increasing prices (Janzen et al. 2014, p. 8). They include restrictions, bans on imports and export taxes (Janzen et al. 2014, p. 8). They occurred in Kazakhstan, Argentina, Russia, Ukraine, India and Serbia during the 2007-2008 period in which wheat prices spiked (Janzen et al. 2014, p. 8). Russia and other countries formerly a part of the Soviet Union will restrict exports to steady their domestic prices and ensure food security (Janzen et al. 2014, p. 8).

Weather of course is the variable with the ability to change wheat prices significantly. Poor weather tends to result in higher prices. Wheat prices rose in 2007 as Australia planted wheat while still experiencing a second consecutive year of drought (Janzen et al. 2014, p. 10). The drought caused Australia to produce only two-thirds of the wheat its typically does, leading to higher prices (Janzen et al. 2014, p. 10). As the financial crisis began in 2008 and its affects were felt around the world, prices that had risen to high levels by early 2008 began to drop later in the year (Janzen et al. 2014, p. 11). Less economic activity led to a reduction in demand, and wheat prices fell. In August of 2010, experiencing a drought, Russia placed a ban on wheat exports to ensure food security, driving up prices again (Janzen et al. 2014, p. 11). These are examples of both variables unique to wheat and supply and demand fundamentals that impact other commodities. Supply and inventory shocks are significant and long lasting, while economic shocks and foreign market activity tend to have small shocks that cause volatility and temporarily high prices (Janzen et al. 2014, p. 29). The same cannot be said for energy and industrial commodities, which during the 2008 financial crisis were far more significantly affected by macroeconomic variables. The major supply and inventory shocks to wheat prices in recent years occurred in 1996, 2003 and 2008 (Janzen et al. 2014, p. 29). All of these shocks are the result of global production decline during these periods. Events that led to these shocks include the already discussed Australian drought, Russian export ban and global financial crisis. Other variables may be capable of pushing prices away from the expected supply and demand equilibrium, such as geopolitical events, and models are required to measure these effects.

One the more effective methodologies for measuring the effects of weather patterns on wheat prices is to use data from the El-Nino Southern Oscillation (ENSO), an event that causes changes in wind patterns and ocean surface temperatures (Ubilava 2014, p. 1). ENSO has two phases, El Nino and La Nina. El Nino causes surface level warming of ocean temperatures around the equator of the Pacific (Ubilava 2014, p. 2). La Nina has the opposite effect, causing colder than normal temperatures are around the equator of the Pacific (Ubilava 2014, p. 2). El Nino and La Nina events are not occurring at all times, with long periods of normal weather between cycles (Ubilava 2014, p. 2). El Nino events often come after La Nina events, each continuing for several months (USDC). ENSO events normally take place approximately every three years, and some cycles are stronger or weaker than others (USDC). ENSO cycles not only change ocean temperatures, but also affect precipitation levels, with EL Nino bringing droughts and La Nina bringing rain, depending on the region of the world in question (Ubilava 2014, p. 2). Moderate to severe ENSO cycles can have substantial impacts on crop yields and production as a result. As David Ubilava notes in his work "International Wheat Price Responses to ENSO Shocks: Modelling Transmissions Using Smooth Transitions", there is a causal relationship between ENSO cycles and wheat prices (Ubilava 2014, p. 3).

The El Nino cycle and weak La Nina effects are responsible for the Australian drought that drove up wheat prices in 2007 and into 2008 (Janzen et al. 2014, p. 10). Even La Nina can damage wheat production if the effects are too strong, bringing floods to northern Australia that ruin wheat crops (Ubilava 2014, p. 2). In North America and Argentina, it is La Nina, not El Nino that can cause droughts (Ubilava 2014, p. 2). Research shows that an average La Nina leads to a roughly four percent drop in global wheat yield, while El Nino causes about a two percent drop in wheat yields (Ubilava 2014, p. 2). ENSO also has the potential to create increased prices through demand side effects. India and China are two of the largest drivers of wheat prices today, and normally produce enough wheat to meet domestic demand (Ubilava 2014, p. 2). ENSO effects have the ability to reduce Chinese and Indian wheat yields to the point that they are required to import wheat, driving up prices (Ubilava 2014, p. 3). La Nina tends to increase wheat prices, while El Nino reduces wheat prices in North America (Ubilava 2014, p. 10). Because El Nino and La Nina have different effects in different regions of the world, their total impact on production and therefore prices can be softened (Ubilava 2014, p 10-11). As noted before, La Nina causes droughts in North America and Argentina, but brings rain to Australia, and El Nino causes Australia's droughts. La Nina's are still considered to be more damaging to wheat production than El Nino's due to wheat prices rising faster after La Nina shocks (Ubilava 2014, p. 11). La Nina events also have proven to make wheat prices more volatile than EL Nino events, as they have longer mean reversions for wheat prices and can reduce stockpiles by greater amounts (Ubilava 2014, p. 11).

The geopolitical events that will be analyzed in the wheat models include the War in Afghanistan and its eventual spillover into Pakistan, as well as the Russo-Georgian War and the Russia-Ukraine conflict. Pakistan, Russia and Ukraine are all major producers of wheat, and Georgia and Ukraine both play important roles in trade and diplomacy between Russia and the EU. Unlike crude oil, which can be nearly instantaneously extracted, wheat must be planted, grown and harvested, so crops yields affected by geopolitical events would take much longer to recover. There is also no OPEC cartel in the wheat market to manage prices and there is a finite amount of land that can be devoted to wheat production. With separatist and Russian forces occupying wheat producing oblasts of Ukraine, the path analysis and vector error correction models will determine if the conflict has affected wheat prices.

2.3 Aluminum

Aluminum is different from wheat and crude oil in several ways. The first of which is that metals markets have never historically come as close to a stockout as other commodities (Gilbert 1995, p. 385-386). A stockout is when stockpiles are entirely depleted. The fact that stocks cannot go negative, known as the non-negativity constraint, is what is responsible for the sudden and high peaks in the prices of many commodities (Gilbert 1995, p. 393). Troughs of tranquil or normal prices interrupted by high peaks are a common occurrence in commodity prices and are signs of nonlinear responses to variables, as low stocks can amplify the effects of other variables beyond what they would normally be (Gilbert 1995, p. 393). Such conditions lead to non-constant variances in commodity models, and this will be addressed in the path analysis and vector error correction models in different ways. This is not a serious issue for metals, including aluminum, though. Aluminum prices are fairly linear, and have never faced the threat of a stockout (Gilbert 1995, p. 393).

Primary aluminum is the processed version of aluminum oxide. Aluminum oxide is found within bauxite and is reduced to primary aluminum through a smelting process (IAI). Primary aluminum is then traded and consumed in massive quantities around the world for use in industrial and retail goods (Bray 2015). Namely, in recent years aluminum has been increasingly used in autos, planes, and construction and as a replacement for copper (Bray 2015). When the global economy suffers and industrial production slows, the production and consumption of aluminum does, too. Aluminum is a storable commodity though, and so it is up to a producer to decide whether they believe continuing production of aluminum and then storing it during a period of reduced demand is a profitable venture. The Asian financial crisis of 1997 led to lower primary aluminum prices in 1998 and into early 1999 before recovering (IMF). When the European and US recession of the early 2000's occurred, prices again fell in late 2001 and early 2002 (IMF). In both cases, aluminum prices closely followed global industrial production levels (IMF; World Bank).

When Lehman Brother filed for bankruptcy in September 2008 and the severity of the financial crisis was comprehended, aluminum prices plunged, as markets understood that growth in industries requiring aluminum would slow or shrink for the foreseeable future (IMF). Between July 2008 and February 2009, the price of aluminum fell 56.38% (IMF). During the same period the price of crude oil fell 68.49% and the price of wheat fell only 31.53% (IMF; GEM). Aluminum's price collapse was not as strong as crude oil's, but much greater than wheat's during the same time period. This demonstrates that energy and industrial commodities are far more susceptible to shocks in economic activity than agricultural commodities, as was mentioned by the US Department of Agriculture when investigating wheat market shocks (Janzen 2014, p. 3).

Interest rates and exchange rates also influence the price of aluminum, with the same dynamics as crude oil and wheat markets. As US interest rates cause the value of the dollar to appreciate against foreign currencies, the price of aluminum falls, as do the prices of crude oil and wheat (Levi 2005, p. 473). In response to the financial crisis aluminum production was greatly reduced at larger rates than demand reduction, causing a small depletion of stockpiles (IAI). As mentioned earlier, aluminum has never come close to stockout. In 2007, global production was 37,933 kilotons (kt) of aluminum and consumption was 38,130 kt ("How the World…"). In 2008 production dropped to 37,330 kt yet consumption increased to 40,162 kt ("How the World…"). By 2009, production dropped to 34,345 kt but consumption had only fallen to 37,724 kt ("How the World…"). Production levels would not meet consumption levels again until 2012, showing that aluminum producers are far slower to increase production levels during economic recoveries than oil producers ("How the World…"). This may be due to producers trying to raise aluminum prices so as not to operate at a loss. This is quite plausible, as the price of primary aluminum on the London Metal Exchange was $3,012.05 per metric ton in March of 2008, and had fallen to $1,338.06 by February 2009 (IMF). By April 2009, the price had risen back to $2,667.42 (IMF). Even in the first half of 2015, aluminum exporters were operating at losses just to keep cash flows from ceasing ("How the World…").

Currently Asia is the world's largest producer of aluminum, producing 36.6 million tons in 2014, while the rest of the world combined only produced 17.3 million tons ("How the World…"). Similarly to wheat, economic growth in developing countries is the driver behind aluminum prices. As growth in emerging economies slows in recent years, prices and inventories have remained steady while production continues to supply growing demand in North America and Europe (IMF; "How the World…"). China in particular has continued to install smelters and maintain production, placing pressure on foreign competitors ("How the World…").

Another feature of the aluminum market that differentiates it from the dynamics of the crude oil and wheat markets is the relationship between production and price. In the wheat market, production of wheat takes planning and months of time, but its consumption can occur immediately (Gilbert 1995, p. 390). The opposite of this is true for aluminum and other metal commodities. As noted by Gilbert in 1995, aluminum production is dependent on price and consumption levels are determined by lagged prices (Gilbert 1995, p. 390). Smelter energy intensity and power consumption can quickly be increased to raise production levels, but goods and projects that require aluminum as an input will place an order months in advance, expecting prices to be at a certain level when the order is due (this is lagged pricing) (Gilbert 1995, p. 390). Even when prices are low, shutting off and turning back on smelters is expensive, and production does not respond to demand immediately, so often times producers keep smelters running at low levels, possibly accumulating stocks if the cost does not exceed future profits (Gilbert 1995, p. 392). As a result, production increases often commence after demand has driven up prices (as producers predict) (Gilbert 1995, p. 392). Also, while prices are high, production increases so that supply to market comes from stocks (Gilbert 1995, p. 392). In short, in the aluminum market, production levels are determined by price, which is determined by demand.

A variable that the primary aluminum and crude oil markets do share is production capacity. Crude oil must be refined, but there is finite refinery capacity, meaning only so much crude oil can be refined into other products such as gasoline or heating oil in a given amount of time. Similarly, primary aluminum must be smelted from aluminum oxide ore found in mined bauxite, and there is a finite installed smelting capacity. The difference between the two is that crude oil exists on the upstream side of refining and primary aluminum is on the downstream side of smelting.

While China is the largest producer of primary aluminum, it has not experienced any geopolitical events in recent years, and so it is absent from the discussion of geopolitical events affecting aluminum prices. Russia, the second largest producer of aluminum, has engaged in multiple geopolitical events in recent years. The First Chechen War began in December of 1994 and continued until August of 1996 (“First Chechen War”). It was caused by the 1993 declaration of independence by the Chechen Republic of Ichkeria, known today as the Chechen Republic, a republic of Russia (“First Chechen War”). Russia refused to acknowledge the Republic’s independence and fought a war that resulted in between 50,000 and 200,000 military and civilian deaths. It concluded with the Khasav-Yurt Accord, which ended hostilities and was intended to delay decisions on the Republic’s independence until 2001 (“First Chechen War”). The Second Chechen War began in August 1999 though, when Islamic forces from Chechnya invaded Dagestan, a Russian republic (“Second Chechen War”). The conflict officially ended in May of 2000 with the Chechen Republic of Ichkeria losing its independence and becoming the Chechen Republic under Russian control, however an armed resistance continued until April of 2009 ("Second Chechen War"). The conflict resulted in between 54,000 and 75,000 killed civilians and military personnel ("Second Chechen War"). While both conflicts involved a breakaway region within Russia's borders, the conflicts included many foreign fighters on the side of Chechnya. How capable these conflicts were of influencing aluminum prices will be discussed in the next sections.

The Russo-Georgian War will be the third geopolitical event analyzed in the aluminum market. Unlike the wars in Chechnya, the Russo-Georgian War involves an internationally recognized state being invaded by another state. The Russo-Georgian War had the potential to affect aluminum prices for the same reason it could have potentially affected crude oil and wheat prices, which is trade and diplomacy between Russia and Europe.

3. Path Analysis Models

3.1 Crude Oil

3.1.1 Methodology

To measure the effects that variables in commodity markets have upon one another, path analysis models will be used. In order to determine how long geopolitical events affect prices, vector error correction models will be employed. The models incorporate the economic theories of Part 2. The path analysis models and vector error correction models as well as the basic analysis of production decisions allow us to test all four hypotheses. As a result of the volatility of commodity prices, only a handful of variables will be employed in each path analysis model along with the geopolitical events.

Path analysis models are one of two parts of a structural equation model (Suhr, p. 1). Path analysis models allow for a multivariate analysis of specified relationships between variables (Suhr. p. 1). Both direct and indirect relationships can be measured to understand how variables interact with each other (Suhr, p. 9). A variable can be both dependent and independent simultaneously in a path analysis model (Suhr, p. 2). The relationships in path analysis models must be specified before they can be run and the results analyzed, meaning that each path from one variable to another must be grounded in theory (Suhr, p. 1). The path coefficients, which represent the relationship between two variables, are "layered" multiple regressions that account for effects from all other relevant direct and indirect paths in the model (Garbin, p. 1). The path coefficients are not correlation coefficients ("Structural Equation Modelling…" 2011).

The crude oil path analysis contains five exogenous variables and four endogenous variables. The exogenous variables are global demand, the US Dollar Index, and three dummy variables representing the Iraq War beginning in 2003, the Russo-Georgian War of 2008, and the Arab Spring beginning in 2011. The endogenous variables are price, US refinery utilization rates, OECD stocks and global production. The dummy variables are binary, with "0" representing periods when the event is not occurring and "1" representing a time period when the event is occurring. Only the first six months of the Iraq War and Arab Spring are "1"'s, and the Russo-Georgian War is five months, the entirety of the conflict. The reason for using only the first six months of the Iraq War and Arab Spring is to maximize the effects that they can have on the price of oil in the model. If extended for years, they become inaccurate representations of their shocks on the oil market. Six months allows the model to accurately capture the effects of the their shocks on the oil market. The data employed in the models is monthly. Annual data does not provide enough observations to allow for a reliable analysis, and daily data for variables are either unavailable or are too volatile, also resulting in an unreliable analysis. Monthly data is both widely available, and is a frequency with a sufficient number of observations and lower volatility. Monthly data for the US Dollar Index, global crude oil production, OECD stockpiles, US refinery utilization rates and crude oil prices are included. A price index with 2005 set to the value of 100 for a basket of simple averaged spot prices of Dated Brent, West Texas Intermediate, and Dubai Fateh crude oils is used as the price of oil in the model.

Table 3.1

Variable Name	Symbol	Start Date	End Date	Description
Price	PRICE	Dec-93	Dec-14	Price index of crude oil basket (WTI, Dated Brent, Dubai Fateh)
Stocks	STOCKS	Dec-93	Dec-14	OECD crude oil stockpiles
Refinery Utilization Rate	UTIL	Dec-93	Dec-14	US crude oil refinery utilization rate
Production	PROD	Dec-93	Dec-14	Global production of crude oil
Demand	DEM	Dec-93	Dec-14	Global demand of crude oil
US Dollar Index	DXY	Dec-93	Dec-14	US Dollar Index - Major Currencies
Iraq War	IRAQ	Mar-03	Aug-03	US war in Iraq
Russo-Georgian War	GEORGIA	Apr-08	Aug-08	Russian war in Georgia
Arab Spring	ARAB	Dec-10	May-11	Civil war in Iraq and Libya

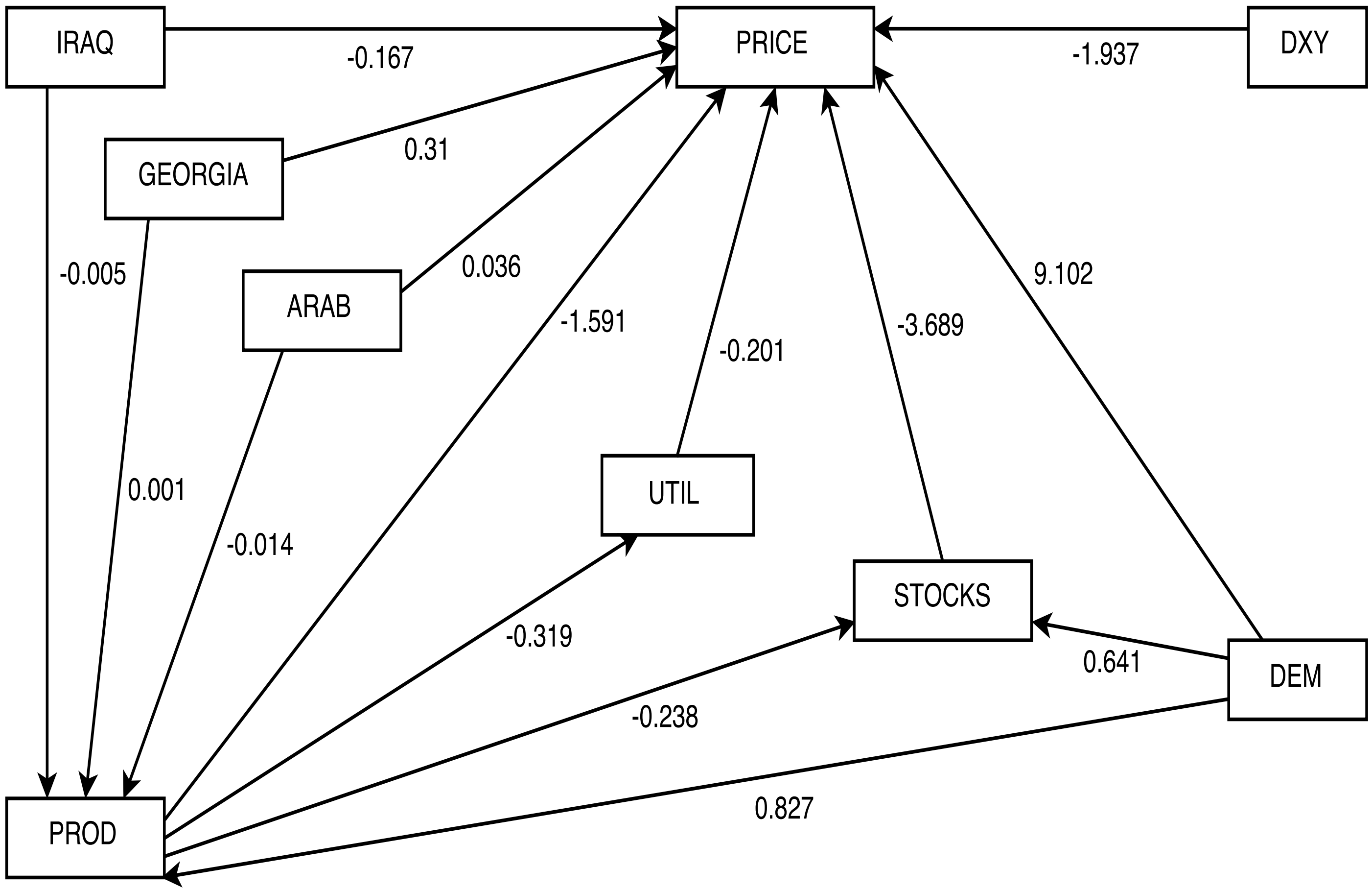
Only annual data is available for global crude oil demand. However, interpolation techniques coupled with the behavior of the variable allows us to convert the annual data into a monthly frequency. Elasticity of demand for crude oil is low, which supports the interpolation of annual data. To calculate demand, monthly mean growth between annual data points is added onto each successive month. Production data is the most important, and it is essential that true monthly production data be employed.

OPEC quotas were removed from the original version of the model due their insignificant effect on prices at a monthly frequency, as well as the changes in total OPEC production being reflected in the monthly global production data. The Federal Funds Rate was also removed from the model due its effects on prices being captured by changes in the dollar value (US Dollar Index) at a monthly frequency. If the model ran at a daily frequency then the Federal Funds Rate would have remained in the model, however at a monthly frequency it proved insignificant. The OECD stockpile data is the most comprehensive stockpile data available, and so it should be the stockpile data used in the real world to determine oil prices. Therefore, despite not being global data, it is sufficient for this model. The US is one of the only publishers of refinery utilization data and so that should be the data that impacts oil prices. Once again, it is not global data, but as far as the author knows it is the data the global market relies upon. Both the OECD stockpile data and US refinery utilization rates are cited as the data used in other models of the global oil market.

The Iraq War dummy variable lasts from March 2003 through August 2003. The Russo-Georgian War dummy variable lasts from April of 2008 when Russia shot down a Georgian reconnaissance drone until August of 2008 when a ceasefire went into effect ("August 2008 Russian…" 2008). The dummy variable for the Arab Spring begins in December of 2010 and ends in May 2011. Libya, one of the largest oil producers in the world prior to the Arab Spring and a member of OPEC, qualifies as a geopolitical event under the definition implemented in this paper. This is so considering that NATO played a pivotal role in deposing Muammar Gaddafi's regime (Kuperman 2013). The War in Afghanistan beginning in 2001 and the Russian invasion of Ukraine in 2014 are not included in the model. The War in Afghanistan has had no discernable affect on monthly crude oil prices, and the Russian invasion is so recent that there is not enough data at this time to conduct an accurate analysis of its effects on crude oil markets.

Figure 3.1

Oil Path Analysis Model



Source: Author's analysis

3.1.2 Results

The path analysis model of crude oil confirms the underlying economic theory presented in Part 2, and allows for the acceptance of hypothesis one that geopolitical events do not have substantial impacts on crude oil prices. The results also strongly support the third hypothesis that price rises coinciding with geopolitical events are in fact caused by variables unrelated to geopolitical events. The data set uses natural logarithms, so the results are in double-log form. This means that a one percent change in one variable leads to a certain percentage change in another variable. In the case of path analysis models, the path coefficient represents the resulting change in one value from a one percent change in another. The coefficients are to the right of or below each path in Figure 3.1.

Beginning with demand, the path coefficient from demand to production is 0.827, indicating that when demand increases, so does production. The coefficient from demand to stockpiles is 0.641, and the coefficient from production to stockpiles is -0.238. Theoretically, the path coefficient from demand to stockpiles should be negative and the coefficient from production to stockpiles should be positive; as demand increases, stockpiles decrease, and as production increases, stockpiles should increase. This doesn't occur in the path analysis, though. There are two possible reasons for this; the first is that the production and demand data are global while the stockpiles data is only for OECD countries only, and OECD stockpiles do not represent global stockpiles well. The second possible reason for this is mentioned by Pesenti & Groen (2011, p. 4), who credits Kilian (2009) with the theory that there are stockpile build-ups preceding periods of expected increased demand. In addition, if increases in demand outpace increases in production, stocks will decrease. For a negative production-to-stocks coefficient to be realized, demand must outpace production more often than it does not. When one considers the coefficient of 0.827 from demand to production that shows production only increases by 0.827% for every 1% increase demand over the course of the time period covered in the data set, such a situation is entirely plausible.

The path coefficient from global crude oil production to US refinery utilization rates is -0.319, which is small, but still negative, the opposite of what it should be theoretically. As production increases, so should refinery utilization rates, however in a situation similar to the OECD stocks, US refinery utilization rates may not represent global refinery utilization well. This is the data that is available to markets though, and so its effects on price should still be accurate. Despite the path coefficient from utilization rates to price being the only non-geopolitical event variable in model with a p-value (0.376) greater than 0.05, the fit indices' values of the model increase with the inclusion of the variable. It will remain in the model on theoretical grounds. The negative path coefficient from utilization rates to price is theoretically correct, and is -0.201. Dees (2008) tested the relationship between utilization rates and crude oil prices and found that increases in utilization rates decrease oil prices.

The path coefficient from stocks to price is -3.689, indicating that a one percent increase in stocks leads to over a three and a half percent decrease in the price of crude oil, as would be expected. The path coefficient from production to price is -1.591, indicating that an increase in production lowers prices, which is theoretically correct. The path from demand to price is 9.102 showing that small increases in demand can have large effects on price. The coefficient from the US Dollar Index to price is -1.937, as it should be. This, along with an earlier iteration of the model including interest rates, proved that an increase in US interest rates leads to an increase in the value of the US dollar, which leads to a decrease in the price of oil.

The last path coefficients to discuss are the geopolitical event dummy variables. The Iraq War has a coefficient of -0.005 and p-value of 0.379 to production, indicating that the war had no effect on the ability of global producers to maintain supply to the market. Global production actually increased dramatically during this time, to levels that eventually placed strain on refinery capacity and forced prices to rise, as discussed in Part 2. This results in the Iraq War variable having a significant p-value of 0.011 and a weak negative coefficient of -0.167 with the price of crude oil. The short-term effects of the Iraq War are represented by a weakly negative coefficient, and the complex interaction of multiple variables during the onset of the Iraq War likely prevented the model from accurately measuring the immediate effects of the war on the price of crude oil. The author disputes the path coefficient from the Iraq War to the price of crude oil, believing that the effects of the Iraq War are masked by the complex interactions of multiple variables during this time period. The author believes that the Iraq War did in fact have a positive but short-lived effect on the price of oil. This will be investigated further when examining the second hypothesis. To be thorough, an extra iteration of the path analysis model was run with adjusted data for the Iraq War, which included the three months preceding the war. The results were unchanged however, as the Iraq War to price path coefficient remained weakly negative but significant. Actions taken by OPEC also stifled the effects of the Iraq War on prices, through changes in member states' target production allocations (OPEC Table 1.2; "Oil Summit Highlights…" 2003).

The path from the Russo-Georgian War to production has a p-value of 0.896 and a coefficient of 0.001, showing that the war didn't impact production, which actually increased by small amounts during the conflict. During this war Russian production did not slow, as the conflict took place within Georgia, accounting for why the war has such a weak coefficient with production. The path coefficient between the Russo-Georgian War and crude prices is positive at 0.31, with a p-value of 0.000, indicating that the war had a small effect on the price of crude oil. This price increase was caused by fears that Russia would limit oil supplies to Europe, however once tensions eased, these fears disappeared (Newnham 2011, p. 137). The Russo-Georgian War came to a close immediately before prices dropped to levels far below where they were when hostilities began (IMF). Whether the effect on prices is long-term will be determined in Part Four.

The Arab Spring, which has devolved into a series of civil wars involving numerous outside actors, has a coefficient of -0.014 with production and a p-value of 0.031. Despite the conflict involving multiple prominent oil producers, world oil production has increased in recent years as the world economy recovered from the global financial crisis (EIA). The Arab Spring has a genuinely weak path coefficient of 0.036 and a p-value of 0.599 with crude oil prices, making it an insignificant variable. Although the conflicts originating from the Arab Spring are still ongoing, the length of time for which it was capable of influencing oil prices will be examined in Part 4. The geopolitical events have much weaker direct relationships with the price of oil than all other variables that have direct relationships with oil prices. The path analysis confirms many of the underlying economic theories described in Part 2. It also allows us to accept the first hypothesis that geopolitical events do not have substantial effects on crude oil prices, while greatly supporting the third hypothesis that long-term price rises are the result of supply and demand fundamentals as well as the economic decisions of governments and organizations, not geopolitical events.

Fit indices are employed to ensure that all of the path analysis models are of an acceptable quality. The Comparative Fit Index (CFI) of the oil model is 0.955, the Tucker Lewis Index (TLI) is 0.9 (rounded from 0.895), and the (SRMR) is 0.058. The cutoff for the CFI is 0.95 or higher, the cutoff for the TLI is 0.9 or higher and the standardized root mean square residual (SRMR) must be below .08. The model meets these requirements, which indicates that it is an acceptable model. It is also worth noting that the R-squared of the price variable in the oil path analysis is 0.954.

3.2 Wheat

3.2.1 Methodology

The wheat path analysis includes seven exogenous variables and three endogenous variables. The exogenous variables include global demand, the US Dollar Index, El Nino events, La Nina events, the War in Afghanistan beginning in 2001, the Russo-Georgian War in 2008, and the Russia-Ukraine conflict beginning in 2014. Available wheat data that runs through April of 2016 allows us to test weather the Russia-Ukraine conflict has a long lasting effect on wheat prices during the 19 months from the conflict's conclusion to the end of the data set, something that couldn't be done for crude oil due to a lack of recent data. The data set begins in December of 1993, the same date as the oil data set, though. The endogenous variables include global production, global stockpiles and the price of US No.1 Hard Red Winter Wheat (Texas Gulf F.O.B.). US No.1 Hard Red Winter shipped from the Texas Gulf at a Freight on Board price is used because it doesn't include transportation costs (which means the producer receives payment only for the cost of the wheat) and is average in protein content and milling quality, making it a good benchmark for global wheat prices.

Monthly data is used in the model. The data on global demand, production and stockpiles is actually annual demand, production and stockpile estimations published at a monthly frequency (WAOB). Beginning in May of each year an estimate of annual demand, production and stockpiles is published by the World Agricultural Outlook Board and US Department of Agriculture (WAOB). Each month the predicted values are adjusted to more accurately estimate what global demand, production and stockpiles will be by the following May, one year after the initial estimation was released. The monthly fluctuations in estimates of annual demand, production and stockpiles reflect changes in predicted weather patterns and economic activity as well as other variables relevant to demand and production levels (WAOB).

Table 3.2

Variable Name	Symbol	Start Date	End Date	Description
Price	PRICE	Dec-93	Apr-16	Price of US No. 1 Hard Red Winter (Texas Gulf F.O.B.)
Stocks	STOCKS	Dec-93	Apr-16	Predicted global stockpiles of wheat
Production	PROD	Dec-93	Apr-16	Predicted global production of wheat
Demand	DEM	Dec-93	Apr-16	Predicted global demand of wheat
US Dollar Index	DXY	Dec-93	Apr-16	US Dollar Index - Major Currencies
El Nino	EL NINO	N/A	N/A	EL Nino weather events
La Nina	LA NINA	N/A	N/A	La Nina weather events
Afghanistan War	AFGHAN	Sep-01	Feb-02	US war in Afghanistan
Russo-Georgian War	GEORGIA	Apr-08	Aug-08	Russian war in Georgia
Ukraine Conflict	UKRAINE	Feb-14	Sep-14	Russian war in Ukraine

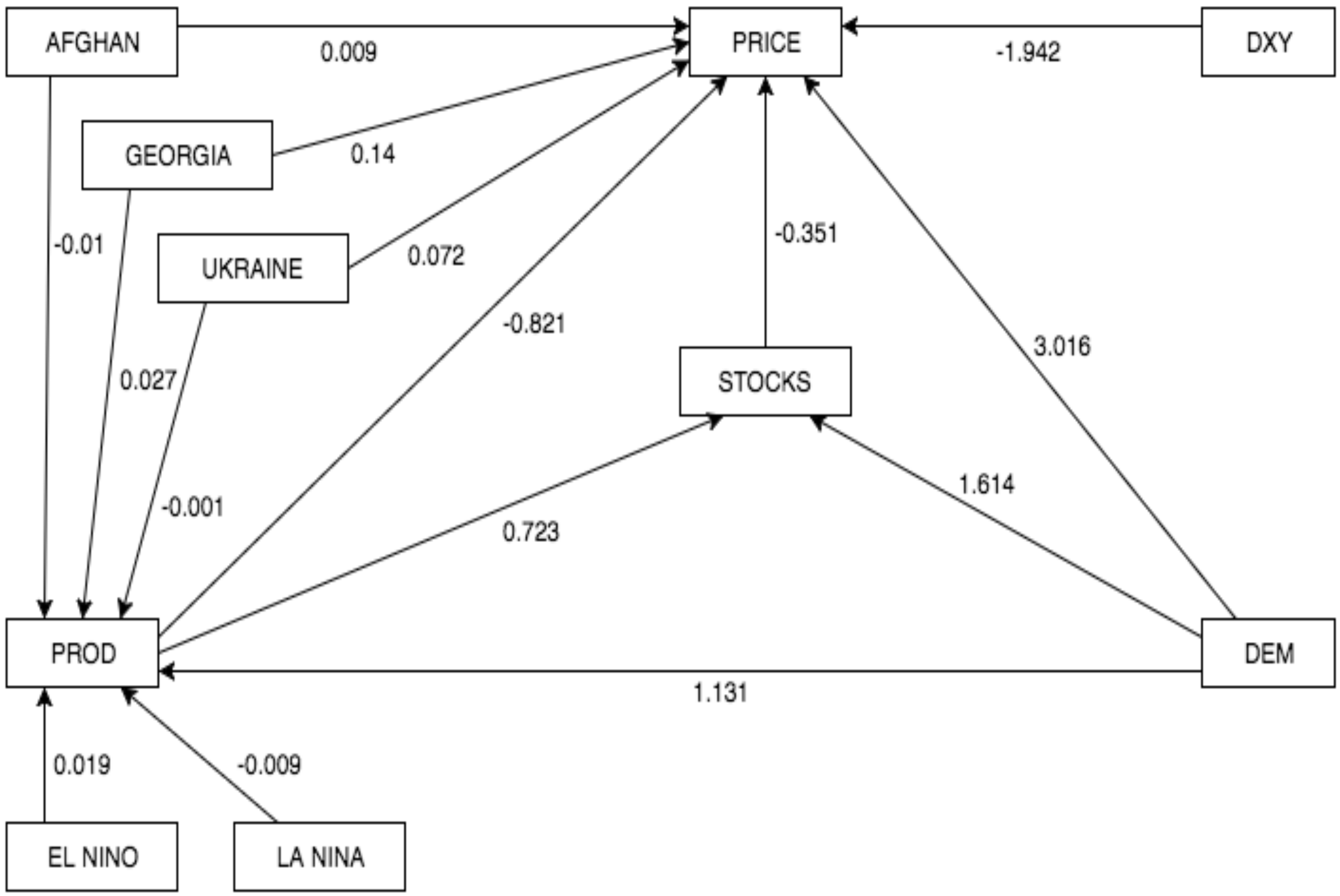
As a result of the demand, production and stockpile data being predictions that account for occurring and predicted exogenous variables, there are no paths from the El Nino and La Nina variables to the price variable in order to avoid misspecification of the model. Instead, paths run only to the production variable to confirm the reliability of the production, demand, and stockpile estimates employed in the data sets. El Nino and La

Nina are split into two separate dummy variables, as there are long periods of normal weather patterns when neither event is occurring. This also allows the measurement of their effects on production individually. Not all ENSO cycles between December of 1993 and April of 2016 are included in the data. Only moderate to severe ENSO events are included to ensure that the model estimates are accurate.

The War in Afghanistan dummy variable runs from September 2001 until February of 2002, then runs again from March of 2004 through August of 2004. The Afghanistan dummy variable is active twice due to the war spilling over in Pakistan in 2004 (Yamin & Malik 2014, p. 5). Afghanistan is not a major wheat producer, however it's neighbor Pakistan is the seventh largest producer in the world (FAO). Both the onset of the War in Afghanistan and the spillover in 2004 that initiated the War in Waziristan may potentially impact wheat prices, and so both events are included in the dummy variable. The Russo-Georgian War dummy variable is identical to the one used in the oil path analysis. The Russia-Ukraine conflict dummy variable begins in February 2014 and runs through September 2014, an eight-month period. In February 2014, Russian troops moved into Crimea, and combat in Eastern Ukraine continued uninterrupted until September 5th, with the signing of the Minsk Protocol that brought a ceasefire into effect ("The Ukraine Crisis…"). With the Russia-Ukraine conflict dummy variable ending in September 2014 and the data running through April 2016, that provides a period of 19 months to determine if the conflict had a long-term effect on wheat prices in the VECM model.

Figure 3.2

Wheat Path Analysis Model



Source: Author's analysis

3.2.2 Results

The path analysis model output for wheat confirms hypothesis one and supports the third hypothesis, that geopolitical events do not have substantial impacts on commodity prices and that demand and production fundamentals are responsible for price increases. Once again, the model is in double-log form. The variables that influence production will be discussed first. The path coefficient from demand to production is 1.131 and is significant with a p-value of 0.000, indicating that a 1% increase in demand leads to a 1.131% increase in production. The El Nino events have a path coefficient of 0.019 with a p-value of 0.000 and the La Nina events have a coefficient of -0.009 and a p-value of 0.05, making both significant. The small coefficients of El Nino and La Nina support previous research that their effects are widely varied across different regions, which can offset the damage done to global wheat production over a year. More than anything, their significance in the model shows that production, demand and stockpile estimates released by the World Agricultural Outlook Board and US Department of Agriculture are accurate. The War in Afghanistan and spillover into Pakistan proved not to have an impact on wheat production, with a coefficient of -0.01 and a p-value of 0.0189. The Russo-Georgian War has a path coefficient of 0.027 to production and a p-value of 0.015, an unusual result that suggests the conflict did not impact production. The Russia-Ukraine conflict certainly did not impact production, with a p-value of 0.898.

When demand increases, stocks increase, too. There is a path coefficient of 1.614 from demand to stocks with a p-value of 0.000. This is typically the result of a precautionary build up of stockpiles in response to expected increased demand in agricultural markets. This is more necessary for agricultural commodities considering their supply is very inelastic. Once a wheat crop is planted, its yield is what will be harvested and supplied to market, and no more wheat can be supplied until another harvest begins. While harvests are ongoing across the world most months of the year, a shortfall in a harvest yield in one region means imports from another are required. Stockpiles can provide the extra supply needed to export wheat to regions with poor harvests without raising prices too much. The path coefficient of production to stocks is 0.723 with a p-value of 0.008; as production rises, so do stocks, as long as demand doesn’t outpace production.

The path coefficient of production to price is -0.821 with a p-value of 0.037, indicating that a 1% increase in production leads to an approximately 0.8% drop in wheat prices. Demand has a path coefficient of 3.016 to price with a p-value of 0.000 proving that prices increase rapidly with increases in demand, similar to crude oil. Stocks are significant and have a p-value of -0.351, showing that an increase in stocks typically lowers the price of wheat. The US Dollar Index also proved significant and has a path coefficient to price of -1.942, indicating that when the dollar appreciates, the price of wheat decreases by a near identical amount as crude oil. This also means that interest rate increases will lower the price of wheat.

The War in Afghanistan with spillover into Pakistan proved to be insignificant with a p-value of 0.856 for its path to wheat prices. The Russo-Georgian War came close to being significant with a coefficient of 0.14, but did not quite meet the 0.05 cut off, with a p-value of 0.068. At 5% significance level, we cannot reject the null hypothesis that the Russo-Georgian did not impact wheat prices. However, at a 10% level we could reject the null hypothesis. The Russia-Ukraine conflict also proved insignificant with a p-value of 0.245. The reasons why none of these geopolitical events proved significant despite involving major wheat producers will be discussed further in Part Five.

The CFI of the model is 0.971, and the TLI is 0.922, both of which are excellent fit indices that indicate the model is acceptable. The SRMR is 0.033, also a strong indication that model is of an acceptable quality. The fit indices are excellent despite the inclusion of insignificant geopolitical variables in the model. The R-square of the price variable is 0.78, showing that the model explains movements in wheat prices quite well. The R-square for production is 0.929, and the R-square of stocks is 0.719, which indicates the changes in production and stocks are also well accounted for in the model. The results from the model allow us to accept the first hypothesis for wheat and strongly support the third hypothesis.

3.3 Aluminum

3.3.1 Methodology

The aluminum path analysis includes six exogenous variables and three endogenous variables. The exogenous variables include interpolated data on electrical power consumption for smelting aluminum oxide into primary aluminum, a global industrial production index, the US Dollar Index, and the geopolitical events of the First Chechen War beginning in 1994, the Second Chechen War beginning in 1999 and the Russo-Georgian War of 2008. The endogenous variables include the price of primary aluminum, global primary aluminum production and global primary aluminum stocks.

The price of primary aluminum is the London Metal Exchange 99.5% minimum purity spot price in US dollars for metric tons. The London Metal Exchange price of aluminum is used worldwide as the benchmark price for aluminum (Gilbert 1995, p. 390). Historical primary aluminum demand data was unavailable, so a global industrial production index has been constructed instead. Using monthly global industrial production data, the January 2005 value was equated to 100, so that any values lower than the January 2005 value of industrial production will be proportionally below 100, and any values above the January 2005 value will be proportionally above 100. Industrial production levels are closely related to aluminum consumption levels, allowing an industrial production index to act as an acceptable substitute for demand. There is a path in the model from the industrial production index to primary aluminum production since it is replacing demand data. There is also a path from industrial production to price. This can offer an understanding of not only how demand for aluminum affects prices, but also how economic activity affects prices, too. The industrial production index is quite literally a measurement of economic activity, and its role as a substitute for demand is almost secondary.

As discussed in Part 2, production of primary aluminum does not affect prices. There is no path in the model from production to prices, but there is path from smelting power consumption to both production and prices. When smelting power increases, production increases. In this way, smelting power consumption also acts as a variable somewhere between production and delayed indications of changes in demand. With China increasing installed smelting capacity each year, it is surely negatively impacting aluminum prices to some degree ("China and Trade"). The smelting power consumption variable will possibly provide an understanding of how China's rapidly growing and massive aluminum industry impacts prices. There are paths from production and smelting power consumption to stocks. The path from production to stocks is customary, but the path from smelting power consumption to stocks exists as a unique variable connection. Aluminum stocks are never near a stockout, preventing the volatile prices seen in crude oil and wheat markets, and so the path analysis model provides insight into how aluminum stocks influence prices, and if it is even a significant variable to begin with.

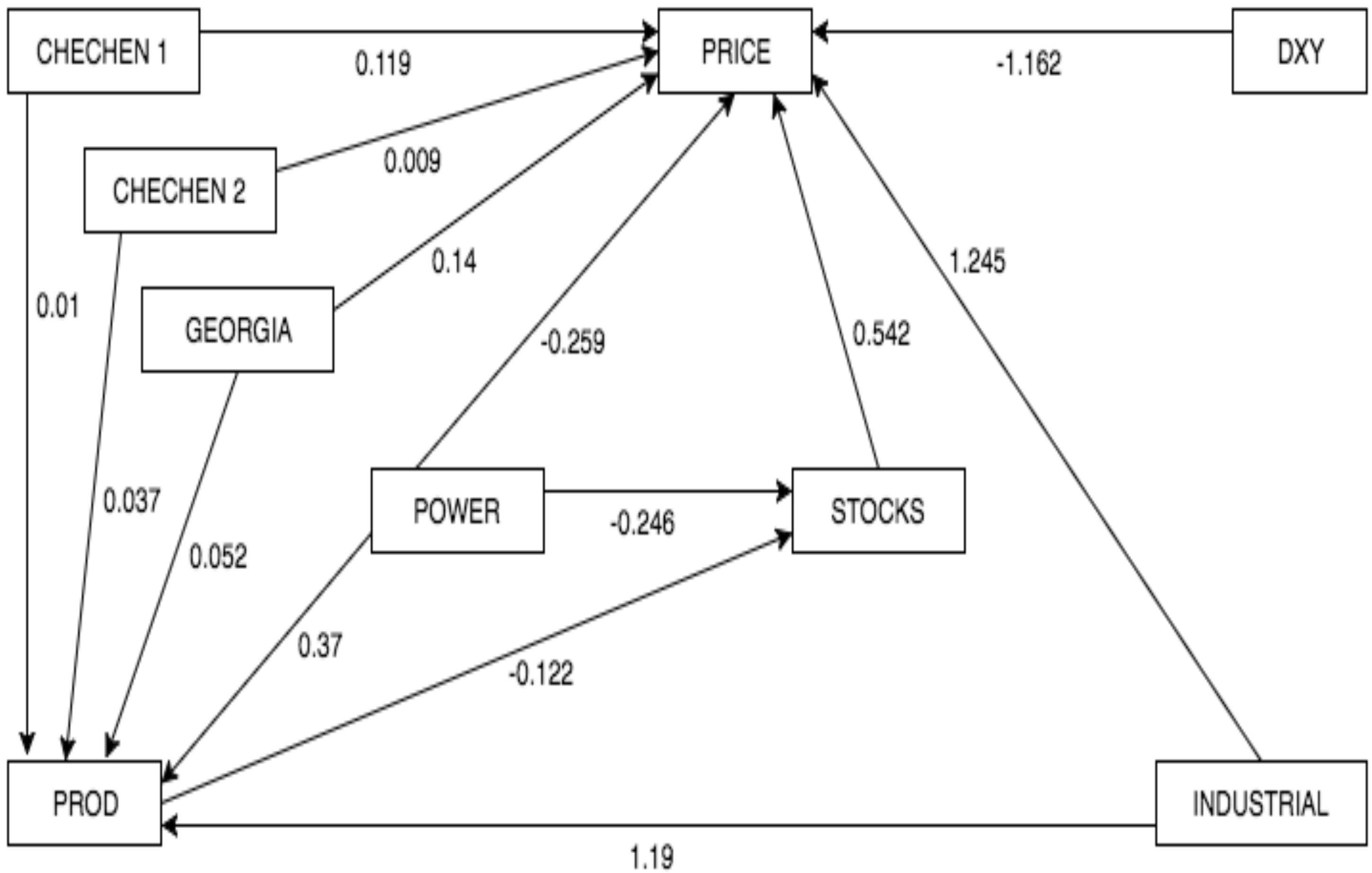
Table 3.3

Variable Name	Symbol	Start Date	End Date	Description
Price	PRICE	Dec-93	Dec-14	London Metal Exchange price of 99.5% purity primary aluminum
Stocks	STOCKS	Dec-93	Dec-14	Global aluminum stockpiles
Smelting Power Consumption	POWER	Dec-93	Dec-14	Global electrical power consumption for smelting aluminum
Production	PROD	Dec-93	Dec-14	Global production of aluminum
Industrial Production	INDUSTRIAL	Dec-93	Dec-14	Global index of industrial production
US Dollar Index	DXY	Dec-93	Dec-14	US Dollar Index - Major Currencies
First Chechen War	CHECHEN 1	Dec-94	May-95	First Russian war in Chechnya
Second Chechen War	CHECHEN 2	Aug-99	Jan-00	Second Russian war in Chechnya
Russo-Georgian War	GEORGIA	Apr-08	Aug-08	Russian war in Georgia

The First Chechen War variable runs from December 1994 through May 1995, and the Second Chechen War variable begins in August of 1999 and ends in January of 2000. Both of the variables run for six months, in attempt to maximize the affect they have on prices being captured in the model. The Russo-Georgian War variable is the same as it was in the crude oil and wheat path analysis models, lasting five months during 2008. Identical to the previous models, there are two paths running from each geopolitical event, with one to price and the other to production. For the sake of being thorough, an iteration of the aluminum path analysis was also run with the Iraq War included, considering that aluminum is an industrial commodity and large-scale wars have the potential to influence industrial production. The iteration of the model with the Iraq War is not the one presented below however, for reasons that will be discussed in the model results.

Figure 3.3

Aluminum Path Analysis Model



Source: Author's analysis

3.3.2 Results

The results from the model again confirm the first hypothesis that geopolitical events do not have major impacts on the prices of commodities and supports the third hypothesis that fundamental variables are the drivers of commodity prices. The data is in double-log form, as were the crude oil and wheat models. The first result to discuss is one that is not included in the above path analysis model. In his work on aluminum markets, Gilbert stated that primary aluminum production does not impact prices (Gilbert 1995, p. 390). In an early version of the above path analysis, a path from production to price was included in order to test his statement. Gilbert proved correct, as the path coefficient from production to price has a p-value of 0.857.

The path coefficient of 0.37 from smelting power consumption to production shows that a 1% increase in power consumption leads to a 0.37% increase in production. The path coefficient from the industrial production index to production is 1.19 indicating that production levels rise with increased demand for aluminum. The First Chechen War proved to not significantly affect production with a p-value of 0.649. The Second Chechen War came close to being significant with a p-value of 0.089, but still does not meet the 0.05 cut to be have been determined to have at least a short-run impact on production. The Russo-Georgian War has a p-value of 0.031, which means that it is significant, however it's path coefficient to production is 0.052. With such a small path coefficient, any increase in primary aluminum production attributed to the brief and small Russo-Georgian War is likely inaccurate.

The path coefficient from smelting power consumption to stocks is -0.246, and is significant. The coefficient from production to stocks is -0.122 and is also significant. This is in line with theory regarding stocks in aluminum markets. When production increases as a response to changes in aluminum prices caused by changes in demand, producers will also sell aluminum that is stockpiled while prices are high. In other words, when production increases, stocks actually decrease. An increase in smelting power consumption indicates a simultaneous increase in production that is a delayed response to increased demand, which will decrease stockpiles if demand is great enough.

The path coefficient from the US Dollar Index to the price of primary aluminum is -1.162, indicating that interest rates and exchange rates share the same relationship with the price of aluminum that they do with crude oil and wheat prices. The industrial production index has a path coefficient of 1.245, showing that increased economic activity and therefore demand leads to an increase in prices. This 1.245% increase in prices from a 1% increase in demand or economic activity is a much weaker response than the ones seen in crude oil and wheat markets, and is likely explained by the unique nature of metals markets. Orders for aluminum are planned on lagged prices, and it can take months for prices to respond to increased demand (Gilbert 1995, p. 390). This is furthered by the fact that primary aluminum stocks have never come even remotely close to a stockout in recent decades, meaning that there are never low stocks that amplify the affect of an increase in demand upon price. The path coefficient from smelting power consumption to price is -0.259, which suggests that the massive gains in smelting power capacity and in turn production from China have suppressed primary aluminum prices in recent years, even if only a small amount. The path coefficient from stocks to price is 0.542, a result of short-term excess supply that will balance out with excess demand in the long-term and with demand driving up prices before stocks can be depleted (Gilbert 1995, p. 386).

The First Chechen War has a path coefficient of 0.119 to price, and p-value of 0.028, proving that it had at least a short-term effect on aluminum prices. The Second Chechen War proved insignificant with a p-value of 0.855, and the reasons why it didn't have a short term impact on aluminum prices as the First Chechen War did will be discussed in Part Five. The Russo-Georgian War has a path coefficient of 0.14 with a p-value of 0.017, indicating at least a short-term impact on aluminum prices. While both the First Chechen War and Russo-Georgian War impacted the short-term price of aluminum, it was by very small amounts, as shown in their path coefficients that are smaller than any of the other variables' path coefficients to price.

The fit indices of the aluminum model are excellent, with a CFI of 0.969, a TLI of 0.908 and an SRMR of 0.031. The model is clearly acceptable. The R-square of the price of aluminum is 0.710, the R-square of production is 0.975, and the R-square of stocks is 0.809, showing that all of the fluctuations in the endogenous variables are well explained.

4. Vector Error Correction Models

4.1 Crude Oil

4.1.1 Methodology

The variables used in the vector error correction model (VECM) were chosen from the iteration of the path analysis model with the highest fit indices scores. The order of the VECM variables is crude oil price, OECD stocks, US refinery utilization rates, global crude oil production, global crude oil demand, and the US Dollar Index. The first step of building the VECM was to construct a Vector Autoregressive model (VAR). Using the result of the VAR, lag length criteria tests and the Johansen Cointegration Test were conducted to determine the number of lags and cointegrating relationships that would be used in the VECM. The Johansen Cointegration Test was used because the data employed in the VECM's is non-stationary. When the data is non-stationary (non-constant variances) at level, a unit root is present, indicating a random walk occurs ("Cointegration"). A random walk means that prices are unpredictable. It is common for both financial and commodity data to be non-stationary, the result of high volatility in prices (Baffes 2007, p. 5). As a result of the data being non-stationary and a random walk occurring, the Johansen Cointegration Test is implemented to determine cointegrating relationships between variables (Sorensen, 2005, p. 6). Even if the variables are non-stationary, meaning they drift unpredictably, it is important to know if they drift together, indicating a long-term relationship between the variables (Sorensen 2005, p. 1). Through knowing the order of cointegrated relationships between non-stationary data, spurious regression results can be avoided ("Cointegration"). Once cointegration has been confirmed, VECM's are effective at measuring the long-term relationships of variables.

Of the six lag length criteria, three of them recommended using three lags, while two recommended using two lags. The criteria that recommended three lags included the Likelihood Ratio (LR), the Final Prediction Error (FPE), and the Akaike Information Criterion (AIC). Both the Trace Test and the Maximum Eigenvalue Test within the Johansen Cointegration Test stated that there are two cointegrating relationships between the variables used in the VAR. The vector error correction model was run at three lags with two cointegrated relationships (as indicated by the VAR lag selection criteria and

Johansen Cointegration Test). An intercept, meaning there is no trend within the cointegrating equations and VAR, is used as the trend specification. Once the VECM is calculated, the equation for price is estimated to derive p-values of all the variables that affect price. An autoregressive conditional heteroskedasticity (ARCH) methodology was used to estimate the price equation of the VECM, as oil prices are inherently volatile and have weak stationarity (non-constant variances) even after first differencing the data. The ARCH methodology removes heteroskedasticity from the model, improving the accuracy of the model output.

Table 4.1

Oil Vector Error Correction Model

Variable	Symbol	Coefficient	Std. Error	z-Statistic	Prob.
(PRICE, UTIL, PROD, DEM, DXY)	C(1)	-0.096269	0.021061	-4.571075	0.0000
(STOCKS, UTIL, PROD, DEM, DXY)	C(2)	-0.658301	0.177698	-3.704606	0.0002
PRICE(-1)	C(3)	0.165257	0.081400	2.030176	0.0423
PRICE(-2)	C(4)	0.049270	0.081488	0.604629	0.5454
PRICE(-3)	C(5)	-0.004303	0.066305	-0.064896	0.9483
STOCKS(-1)	C(6)	-1.468929	0.491740	-2.987206	0.0028
STOCKS(-2)	C(7)	0.573514	0.607489	0.944073	0.3451
STOCKS(-3)	C(8)	0.599524	0.549362	1.091310	0.2751
UTIL(-1)	C(9)	0.360671	0.156286	2.307757	0.0210
UTIL(-2)	C(10)	0.555541	0.170386	3.260496	0.0011
UTIL(-3)	C(11)	0.489861	0.191587	2.556866	0.0106
PROD(-1)	C(12)	0.800026	0.603889	1.324790	0.1852
PROD(-2)	C(13)	-0.097592	0.616145	-0.158392	0.8741
PROD(-3)	C(14)	-0.248677	0.564782	-0.440305	0.6597
DEM(-1)	C(15)	1.368231	1.630401	0.839199	0.4014
DEM(-2)	C(16)	0.328379	1.570807	0.209051	0.8344
DEM(-3)	C(17)	0.589157	1.324253	0.444898	0.6564
DXY(-1)	C(18)	-0.307322	0.349123	-0.880268	0.3787
DXY(-2)	C(19)	-0.172477	0.325221	-0.530336	0.5959
DXY(-3)	C(20)	0.060441	0.340037	0.177750	0.8589
INTERCEPT	C(21)	0.004038	0.006196	0.651732	0.5146
IRAQ	C(22)	-0.057855	0.033104	-1.747677	0.0805
GEORGIA	C(23)	0.039155	0.024789	1.579515	0.1142
ARAB	C(24)	0.011295	0.024226	0.466244	0.6410

Source: Author’s analysis

4.1.2 Results

The variables of C(1) and C(2) in the price equation of the VECM output are the cointegrating models and their coefficients are the error correction terms. They represent the joint relationship of oil market fundamentals (all of the variables except the geopolitical events) that affect the price of crude oil. These equations lie within a larger equation for the price of oil with variables for lags and the geopolitical dummy variables.

The variable of C(1) proved significant in the long term with an error correction term (ECT) of -0.096269 and a p-value of 0.0000, and the variable of C(2) proved significant with an ECT of -.658301 and p-value of 0.0002 showing that all of the non-geopolitical event variables influence the price of oil in the long run. None of the geopolitical events were proven to significantly affect the price of oil in the long term. The Iraq War has a p-value of 0.0805, the Russo-Georgian War has a p-value of 0.1142, and the Arab Spring has a p-value of 0.6410. They are represented in the model by C(22), C(23) and C(24), respectively. While we cannot reject the null hypothesis of no long-term effects at the 5% significance level for the Iraq War, we could reject it at the 10% significance level. The author would argue that the 5% significance level is appropriate, and refers to the path analysis model results concerning the Iraq War; it is improbable that the Iraq War had a long-term effect on crude oil prices when even it's short-term effects are questionable.

The residual diagnostic used to determine if the VECM is an acceptable model is the ARCH LM Test. The p-values of the Chi-Square of the Observed R-squared and F-statistic is 0.5166 and 0.5208, which are greater than 0.05, allowing the acceptance of the null hypothesis that there is no ARCH heteroskedasticity present in the model's residuals. The R-squared of the vector error correction models is low, however this is acceptable for two reasons. The first is that the variables used were chosen from a path analysis model with high fit indices, and so it is theoretically sound. The second is that commodities are volatile and R-squared is often accepted as a meaningless measurement when dealing with commodity prices. The following is from "Time Series Econometrics and Commodity Price Analysis" by Robert Myers in 1994:

> "Certainly, highly volatile prices may be difficult to explain using standard econometric models and techniques, so that the R^2 in equations trying to explain price movements may be quite small. This in itself, however, poses no particular statistical problems. The challenge presented by highly volatile commodity prices lies in explaining why the volatility occurs and deciding what, if anything, needs to be done to alleviate any undesirable consequences." (Myers 1994, p. 172)

The R-squared of the price of oil in the path analysis is 0.954 however, indicating that the path analysis model explains nearly all of the movement in the price of oil. The results of the vector error correction model confirm the third hypothesis by proving that geopolitical events do not have long-term effects on crude oil prices.

4.2 Wheat

4.2.1 Methodology

The vector error correction model for wheat was built with the variables from the iteration of the path analysis model with the highest fit indices, as was the crude oil model (trade variables have been removed from previous iterations). A VAR model was built using the price of wheat, stocks, production, demand and the US Dollar Index as endogenous variables, and the War in Afghanistan, the Russo-Georgian War, and the Russia-Ukraine conflict were used as exogenous variables, in addition to a constant. Lag length criteria and the Johansen Cointegration Test determined that two lags and one cointegrating relationship should be included in the model. Specifically the LR, FPE and AIC criteria recommended two lags. The Trace Test of the Johansen Cointegration Test states that there is one cointegrating relationship.

The vector error correction model was run with an intercept as the trend specification, stating that there is no trend. The VECM was calculated and the resulting equation for the price variable was estimated separately to determine the p-values of all variables in the equation. A Least Squares (NLS and ARMA) methodology is used to estimate the price equation, with an HAC (Newey-West) covariance methodology to control for heteroskedasticity (caused by changing periods of volatility and tranquility) and autocorrelation.

Table 4.2

Wheat Vector Error Correction Model

Variable	Symbol	Coefficient	Std. Error	t-Statistic	Prob.
(PRICE, STOCKS, PROD, DEM, DXY)	C(1)	-0.020929	0.009920	-2.109883	0.0359
PRICE(-1)	C(2)	0.233711	0.052264	4.471724	0.0000
PRICE(-2)	C(3)	-0.139832	0.060184	-2.323400	0.0210
STOCKS(-1)	C(4)	-0.125790	0.125391	-1.003180	0.3167
STOCKS(-2)	C(5)	-0.173658	0.089216	-1.946490	0.0527
PROD(-1)	C(6)	0.209413	0.356616	0.587223	0.5576
PROD(-2)	C(7)	0.052833	0.424691	0.124402	0.9011
DEM(-1)	C(8)	-0.425600	0.609896	-0.697824	0.4859
DEM(-2)	C(9)	-0.182551	0.972839	-0.187648	0.8513
DXY(-1)	C(10)	-0.196297	0.284704	-0.689479	0.4912
DXY(-2)	C(11)	0.123655	0.290583	0.425541	0.6708
INTERCEPT	C(12)	0.003207	0.004042	0.793397	0.4283
AFGHAN	C(13)	-0.017543	0.013928	-1.259491	0.2090
GEORGIA	C(14)	-0.029603	0.039725	-0.745211	0.4568
UKRAINE	C(15)	-0.006643	0.031458	-0.211159	0.8329

Source: Author's analysis

4.2.2 Results

There is only one cointegrating model in the wheat VECM and it is represented by C(1). The variable of C(1), which represents price, stocks, production, demand and the US Dollar Index has a coefficient or ECT of -0.020929, and a p-value of 0.0359 meaning that all of the fundamental variables in the model jointly impact the price of wheat throughout the length of the data set. None of the geopolitical events have significant p-values. The War in Afghanistan has a p-value of 0.2090, the Russo-Georgian War has a p-value of 0.4568, and the Russia-Ukraine conflict's p-value is 0.8329. They are represented in the output by C(13), C(14) and C(15) respectively. This should not be surprising, considering the path analysis model also determined that none of the geopolitical events significantly affected prices.

The residual diagnostics of the VECM include the Breusch-Godfrey Serial Correlation LM Test and the Breusch-Pagan-Godfrey Heteroskedasticity Test. The serial correlation test has an Observed R-squared p-value of 0.1123, and the Chi-square p–value of the F-statistic is 0.1270, which means that we cannot reject the null hypothesis that there is no serial correlation in the residuals of the model. Regarding the heteroskedasticity test, the p-value of the Chi-Square for the Observed R-squared test statistic is 0.2108, and for the F-statistic it is 0.2097, meaning that we cannot reject the null hypothesis that there is no heteroskedasticity in the residuals of the model. The output from the VECM for wheat allows once again for the acceptance of the third hypothesis, proving that geopolitical events do not influence wheat prices in the long-term.

4.3 Aluminum

4.3.1 Methodology

The vector error correction model for aluminum was built using variables from the path analysis model with the highest fit indices scores. The initial VAR was built using variables in the order of price, stocks, production, smelting power consumption, the industrial production index and the US Dollar Index for endogenous variables. The First Chechen War, Second Chechen War, and Russo-Georgian War were used for exogenous variables, and the Iraq War was not included, despite being employed in previous iterations of the aluminum path analysis model. Production is included in the model because it has cointegrating relationships with variables, even if it doesn't directly influence price.

Lag length criteria including the LR, FPE and AIC criteria indicate that four lags should be used in the VECM model. The Johansen Cointegration Test states that there is one cointegrating relationship, both on the Trace Test and Maximum Eigenvalue Test. For the trend specification, no trend was chosen, only an intercept. The resulting price equation from the VECM output was estimated separately to obtain the p-values of all relevant variables. When estimating the price equation for aluminum, a Least Squares (NLS and ARMA) methodology was chosen, with an ordinary covariance methodology, too. Due to aluminum stocks being steady and never near a stock out, prices are not as volatile as for other commodities such as wheat and crude oil. This allows the use of an equation estimation methodology and covariance methodology that doesn't account for autoregressive conditional heteroskedasticity and other conditions that effect the quality of a model.

Table 4.3

Aluminum Vector Error Correction Model

Variable	Symbol	Coefficient	Std. Error	t-Statistic	Prob.
(PRICE, STOCKS, PROD, POWER, INDUSTRIAL, DXY)	C(1)	-0.089667	0.020631	-4.346165	0.0000
PRICE(-1)	C(2)	0.185913	0.069007	2.694098	0.0076
PRICE(-2)	C(3)	0.088441	0.071827	1.231311	0.2195
PRICE(-3)	C(4)	-0.005631	0.072250	-0.077932	0.9380
PRICE(-4)	C(5)	0.023901	0.070624	0.338417	0.7354
STOCKS(-1)	C(6)	-0.309736	0.149306	-2.074508	0.0392
STOCKS(-2)	C(7)	-0.029890	0.151858	-0.196826	0.8441
STOCKS(-3)	C(8)	-0.051526	0.154285	-0.333968	0.7387
STOCKS(-4)	C(9)	-0.241643	0.152919	-1.580199	0.1155
PROD(-1)	C(10)	0.574271	0.149853	3.832221	0.0002
PROD(-2)	C(11)	0.314528	0.159307	1.974352	0.0496
PROD(-3)	C(12)	0.088411	0.138846	0.636756	0.5249
PROD(-4)	C(13)	0.143145	0.114456	1.250656	0.2124
POWER(-1)	C(14)	0.155982	0.247714	0.629686	0.5296
POWER(-2)	C(15)	-0.140628	0.284591	-0.494141	0.6217
POWER(-3)	C(16)	0.154788	0.285523	0.542122	0.5883
POWER(-4)	C(17)	-0.318782	0.247575	-1.287617	0.1992
INDUSTRIAL(-1)	C(18)	-0.627713	0.198989	-3.154511	0.0018
INDUSTRIAL(-2)	C(19)	-0.451001	0.179305	-2.515266	0.0126
INDUSTRIAL(-3)	C(20)	-0.303388	0.145129	-2.090469	0.0377
INDUSTRIAL(-4)	C(21)	-0.081281	0.107726	-0.754517	0.4513
DXY(-1)	C(22)	-0.032592	0.209329	-0.155700	0.8764
DXY(-2)	C(23)	-0.068390	0.222987	-0.306697	0.7594
DXY(-3)	C(24)	-0.134564	0.219112	-0.614135	0.5398
DXY(-4)	C(25)	-0.357918	0.210160	-1.703074	0.0900
INTERCEPT	C(26)	-0.002499	0.003479	-0.718200	0.4734
CHECHEN1	C(27)	0.021089	0.021534	0.979356	0.3285
CHECHEN2	C(28)	0.036813	0.019636	1.874791	0.0622
GEORGIA	C(29)	-0.028472	0.020926	-1.360561	0.1751

Source: Author’s analysis

4.3.2 Results

The variable of C(1) represents the only cointegrating model in the price equation, containing price, stocks, smelting power consumption, the industrial production index, production and the US Dollar Index. The variable has a coefficient or error correction term of -0.089667 and a p-value of 0.000, indicating that throughout the timespan of the dataset, the fundamental variables were influencing the price of primary aluminum. None of the geopolitical variables proved to have long-term effects on the price of aluminum. The First Chechen War, which proved to be significant in the short-term, has p-value of 0.3285, showing that it is not significant in the long-term. The Second Chechen War, which proved not to be significant in the short-term, has a p-value of 0.0622, which is close to 0.05, but it also has a positive coefficient of 0.036813, which solidifies its status as not having long-term effects either. The Russo-Georgian War, which had short-term effects, proved insignificant in the long-term with a p-value of 0.1751.

The residual diagnostics of the VECM include the Breusch-Godfrey Serial Correlation LM Test, the Breusch-Pagan-Godfrey Heteroskedasticity Test, and and ARCH Heteroskedasticity Test. Regarding the serial correlation test, the p-value of the Chi-square for the Observed R-square statistic is 0.6767, and for the F-statistic it is 0.7102, meaning we cannot reject the null hypothesis that there is no serial correlation in the residuals of the model. The p-value of the Chi-square for Observed R-square the in Breusch-Pagan-Godfrey Heteroskedasticity Test is 0.3476, and the p-value for the F-statistic is 0.3519, indicating that we cannot reject the null hypothesis of no heteroskedasticity in the residuals of the model. The ARCH Heteroskedasticity test was included in the residual diagnostics of this model because the estimation and covariance methods used do not account for ARCH effects. The p-value of Chi-square for the Observed R-square is 0.1401 and the Chi-square p-value for the F-statistic is 0.1412, which are above 0.05 and means there are no ARCH effects present in the model. The results of the aluminum VECM are similar to those of the crude oil and wheat models, confirming the third hypothesis definitively.

5. Local Effects of Geopolitical Events

5.1 Crude Oil

We have briefly covered the responses of oil producers to shocks in within the crude oil market, but in this section we will test the fourth hypothesis using only deductive reasoning and statistics from numerous sources regarding several key indicators to determine how geopolitical events affect the local production of the countries and regions the event is occurring in. To understand on a deeper level how organizations and governments relevant to crude oil respond to shocks, we will perform a very basic analysis of production decisions regarding refinery capacity growth, active rigs, completed wells, and producing wells. We will first examine the Iraq War and Arab Spring, then the Russo-Georgian War.

In February of 2003, OPEC increased its production ceiling from 21.809 million barrels a day to 23.230 million barrels a day (b/d), allocating higher target quotas to member states in preparation for the Iraq War that would begin in March (OPEC Table 1.2). Increases in quotas for each member state rose between 100,000 b/d a day to 500,000 b/d (OPEC Table 1.2). This increase in quotas lasted until June, when quotas were raised again to 24.083 million b/d, before quotas were reduced in November to 23.230 million b/d, a quota that lasted until March of 2004 (OPEC Table 1.2). These actions offset the drop in production in Iraq, whose output decreased from 2.126 million b/d in 2002 to 1.378 million b/d in 2003 as shown in Table 1.0 below (OPEC Table 3.6). By 2004, before sectarian violence had taken hold of the country, Iraqi production was back to 2.107 million b/d (OPEC Table 3.6). Once sectarian violence overtook the country, production dropped to 1.853 and 1.957 million b/d in 2005 and 2006, respectively (OPEC Table 3.6). In 2007 and 2008 production once again began climbing and in 2008 surpassed pre-war levels of production (OPEC Table 3.6). This growth has continued since, despite the Islamic State controlling a significant portion of Iraq. In 2014, Iraq produced 3.110 million b/d (OPEC Table 3.6). During this time OPEC quotas increased, too, until in January of 2012 target production for the whole of OPEC was set at 30 million b/d, where it has remained since, with member states deviating from their quotas by producing slightly more than their target allocations (OPEC Table 1.2).

None of this should come as a surprise, as OPEC over the years has proven more than capable of shifting production allocations among member states in order to meet global demand. What is surprising is that from 1989 through 2007, Iraq maintained exactly 30 active oil rigs, well into the Iraq War (OPEC Table 3.2). In 2008 the number of active rigs fell to 29, and then to 22 in 2009 (OPEC Table 3.2). In 2010, Iraq had 36 active rigs, and as of 2014 operates 69 rigs, peaking at 92 in 2012 (OPEC Table 3.2). In 2003, Iraq had 950 producing wells, which fell to 801 in 2004, before rebounding to 1,480 in 2005 (OPEC Table 3.4). The number of producing wells has grown since to 1,963 in 2014 (OPEC Table 3.4). During this time OPEC's number of active rigs has increased from 234 in 2002 to 855 by 2014, undoubtedly the result of a need to meet growing global demand (OPEC Table 3.2).

Libyan oil production has suffered dramatically since Muammar Gaddafi was removed from power with the assistance of NATO and the country slid into civil war. In 2010 Libya produced 1.487 million b/d, then dropped to 489,456 b/d in 2011 (OPEC Table 3.6). In 2012 and 2013 Libya managed to produce 1.450 million b/d and 993,346 b/d, but in 2014 fell again to only 479,899 b/d (OPEC Table 3.6). In 2010, Libya had 60 active rigs, bottomed out at 23 in 2012, and had risen to 31 by 2014 (OPEC Table 3.2). The number of producing wells was at 2,060 in 2010, and had fallen to 609 by 2011 (OPEC Table 3.4). In 2014 Libya had 632 producing wells (OPEC Table 3.4). Unfortunately, no data for individual country's target allocations are available from November 2007 onward. However, OPEC has managed to increase its quotas and meet them over the years, and sometimes surpasses them (OPEC Table 3.6). Equally important is that Iraq and Libya managed to keep some level of output during conflicts, and that OPEC was able to compensate for their drops in output (OPEC Table 3.6). OPEC's growing number of active rigs and producing wells is strongly correlated with global increases in crude oil refinery capacity data provided by OPEC (OPEC Table 4.3).

Table 5.1.1

Year	Iraq			Libya			OPEC		
	Production (b/d)	Active Rigs	Producing Wells	Production (b/d)	Active Rigs	Producing Wells	Production (b/d)	Active Rigs	Producing Wells
1994	748,677	30	N/A	1,389,827	12	1227	24,199,616	263	25,143
1995	736,890	30	N/A	1,399,038	13	1278	24,260,005	278	22,215
1996	740,421	30	N/A	1,394,005	12	1454	24,499,599	258	26,053
1997	1,383,915	30	N/A	1,395,764	10	1470	25,196,786	249	28,267
1998	2,181,082	30	N/A	1,449,028	8	1425	27,504,181	228	27,558
1999	2,719,843	30	N/A	1,287,185	7	1430	25,955,720	215	25,167
2000	2,809,960	30	N/A	1,347,200	8	1436	27,600,763	220	28,272
2001	2,593,682	30	N/A	1,323,460	9	1545	26,794,141	228	28,806
2002	2,126,496	30	N/A	1,200,900	10	1498	24,469,886	234	26,061
2003	1,377,828	30	950	1,431,900	11	1535	27,048,209	254	26,697
2004	2,107,062	30	801	1,580,700	12	1590	29,982,412	273	27,922
2005	1,853,151	30	1480	1,693,200	25	1685	31,246,436	296	29,935
2006	1,957,224	30	1490	1,751,186	38	1725	31,565,623	355	31,101
2007	2,035,244	30	1508	1,673,900	50	1875	31,123,429	383	35,083
2008	2,280,538	29	1685	1,721,484	63	1543	32,075,362	477	32,113
2009	2,336,181	22	1526	1,473,937	60	2060	28,927,131	460	36,076
2010	2,358,074	36	1526	1,486,605	60	2060	29,249,375	497	35,272
2011	2,652,625	59	1695	489,456	55	609	30,121,157	663	35,078
2012	2,942,407	92	1700	1,449,994	23	1910	32,424,700	761	37,043
2013	2,979,616	83	1735	993,346	31	1308	31,603,785	838	36,435
2014	3,110,471	69	1963	479,899	31	632	30,682,866	855	36,140

Source: OPEC

The Russo-Georgian War had no significant impact on oil production. In 2007 Georgia produced only 57 kilotons of crude oil, and in 2008 production dropped to 53 kilotons (IEA) In 2013, only 48 kilotons of crude oil were produced in Georgia, negligible amounts in the scheme of world crude oil production (IEA). Any short-term effects on the price of crude caused by the Russo-Georgian War were the result of Europe speculating over the security of oil supplied to Europe from Russia (Lyutskanov et al. 2013, p. 37). With the knowledge gained from the path analysis and VECM models, testing the second hypothesis requires only a brief analysis of crude oil prices. The Russo-Georgian War was the only geopolitical event that can be confirmed to have caused an increase in crude oil prices, however both the Russo-Georgian War and Iraq War will be analyzed to confirm the second hypothesis. In February of 2003, one month before the Iraq War began, the price of a barrel of crude oil was $32.88; by April 2003, the price was $25.49, and in August was $29.68 (IMF). In April of 2008, with the Russo-Georgian War beginning to escalate, the price of a barrel of crude oil was $109.05 (IMF). By July the price had risen to $132.55, and in August when the conflict peaked then ended it had dropped to $114.57 (IMF). In October, only one month after the conflict ended, the price of crude oil had fallen to $99.29 (IMF). This shows that in the immediate aftermath of the Russo-Georgian War, the conflict's influence on prices disappeared, and the non-geopolitical variables included in the path analysis model once again became the drivers of crude oil prices. Concerning the Iraq War, crude oil prices actually dropped during its initial stages (IMF). This allows for the acceptance of the second hypothesis that crude oil price reactions to geopolitical events are overreactions and that prices will revert to levels similar to before the event occurred.

Russian production was not affected by the conflict, only slowing in 2008 as a result of the global financial crisis (OPEC Table 3.6). As tensions between Russia and Europe have increased in recent years, Russia has increased it crude oil exports to Asia, increasing its economic security through diversification of trading partners (OEC). Europe is also attempting to reduce its dependence on Russian energy, building liquefied natural gas (LNG) platforms off its coasts (Dickel et al. 2014, p. 1). Europe is aware that Russia's economy is dependent on revenue from energy exports, and fears of Russia shutting off the flow of crude oil through pipelines are low, but likely influenced oil prices during the Russo-Georgian War, if only for a short period of time (Lyutskanov et al. 2013, p. 37). These simple statistics provide a very basic yet clear understanding of how regional or global producers will fill any shortfalls in production by states affected by geopolitical events, assuming there are any significant shortfalls. Such a conclusion allows us to accept the fourth hypothesis for crude oil.

Table 5.1.2

Russia		
Year	Production (b/d)	Share of Exports to Europe
1995	6,033,730	95%
1996	5,861,878	86%
1997	5,955,825	92%
1998	5,885,936	88%
1999	5,905,912	84%
2000	6,246,233	83%
2001	6,727,413	83%
2002	7,381,046	85%
2003	8,205,519	83%
2004	8,910,726	85%
2005	9,147,648	85%
2006	9,358,489	85%
2007	9,572,104	81%
2008	9,498,523	82%
2009	9,650,370	81%
2010	9,841,315	78%
2011	9,943,274	75%
2012	10,042,902	77%
2013	10,146,595	74%
2014	10,221,088	70%

Sources: OPEC; OEC

5.2 Wheat

To analyze how the geopolitical events used in the path analysis and VECM for wheat impacted production in the relevant regions, we will examine wheat fields and the geopolitical events themselves. The War in Afghanistan, or at least the conflict occurring within Afghanistan's borders, does not have the ability to affect wheat prices through changing supply and demand fundamentals. However, one might have thought that speculation of the war spilling over into Pakistan would raise wheat prices. As shown in the path analysis model, neither speculation concerning possibilities in Afghanistan and Pakistan nor the events themselves caused significant changes in wheat prices. The reasons why the War in Afghanistan and the ensuing War in Waziristan did not affect wheat prices despite Pakistan being the seventh largest wheat producer in the world can be explained through a simple analysis of wheat production variables in Pakistan (FAO).

The majority of Pakistan's conflict occurs within the provinces of the Federally Administered Tribal Areas (FATA) and Khyber Pakhtunkhwa (KP), with increasing violence in other border areas (Yamin & Malik 2014). In 2004 the War in Waziristan began and the US also started drone warfare in Pakistan (Yamin & Malik 2014, p. 7). The Uppsala Conflict Data Program considers Pakistan to be a country at war (Yamin & Malik 2014, p. 5). The Durand Line that forms the international border between Afghanistan and Pakistan is disputed by the two countries, and Taliban and Al Qaeda fighters are able to cross the border in certain areas largely unopposed (Perveen et al. 2015, p. 2). The two main points in time during which this conflict could have potentially affected wheat prices are 2001 and 2004.

Table 5.2.1

Year	Production (Thousands of Metric Tons)		
	FATA	Kyber Pakhtunkhwa	Pakistan
2000	103.1	964.7	21,079.0
2001	54.4	709.6	19,024.0
2002	67.3	823.2	18,227.0
2003	87.0	977.4	19,183.0
2004	87.0	938.2	19,500.0
2005	124.9	966.2	21,612.0
2006	352.4	828.1	21,277.0
2007	158.0	922.5	23,295.0
2008	122.6	949.2	20,959.0
2009	116.0	1,088.7	24,033.0
2010	108.1	1,044.4	23,311.0
2011	94.21	1,061.62	25,214.0

Sources: PAIS; FAO

In 2000, the KP province produced 964,700 tons of wheat, but by 2001 it only produced 709,600 tons of wheat (PAIS). In 2002 it produced 823,200 tons and by 2003 wheat levels had risen to pre-war levels of 977,400 tons of wheat (PAIS). A similar picture comes from the neighboring FATA, where production dropped from 103,100 tons in 2000 to 54,400 tons in 2001, and didn't recover until 2005 (PAIS). The war in Afghanistan is not responsible for these drops in provincial production though, droughts are. Pakistan's Rabi crop, or wheat planted in the month of November and harvested in April, was affected by drought (PAIS). In the 1999-2000 season, during the months of December through March when the Rabi crop is growing, precipitation in the KP province reached a season maximum of approximately 60 millimeters in mid-January (PAIS). In 2001, at no point during the growth of the Rabi crop did precipitation exceed 34 millimeters, which it reached in late March towards the end of the growing season (PAIS). At no point in January of February was there a ten day stretch that exceeded five millimeters of rain (PAIS). In December of January and February 2001, precipitation didn't reach more than four millimeters over a ten day period (PAIS). It wasn't until late February and early March the precipitation exceeded 35 millimeters for two consecutive ten day periods (PAIS). In 2003, there was a ten day period in mid-February with approximately 125 millimeters of precipitation (PAIS). After examining the precipitation levels in the KP province between 1999 and 2003 during the growing season of Pakistan's wheat crop, it should come as no surprise that wheat production in the KP and neighboring FATA provinces was below normal during 2001 and 2002. We can confidently state that the War in Afghanistan likely had little to nothing to do with reduced wheat production in Pakistan border areas during 2001 and 2002.

In 2004 when the War in Waziristan and US drone strikes in Pakistan began, production dropped from 977,400 tons in 2003 to 938,200 tons in KP province (PAIS). By 2005 production in KP had risen to 966,200 (PAIS). In FATA where the Waziristan districts are, production had risen to 352,400 tons by 2006 from only 87,000 tons in 2004 despite being the epicenter of the conflict in Pakistan (PAIS). This discussion of conflict, weather and wheat production in Pakistan's most troubled provinces was conducted to prove that despite being in the middle of a war, producers of commodities are often still able to provide supply to market. As shown in Table 2.1, only a small portion of

Pakistan's wheat is grown in the FATA and KP provinces. The vast majority of Pakistan's wheat is grown further east and south where there may still be a Taliban presence, but the conflict is not nearly as intense (PAIS; Yamin & Malik). Furthermore, Pakistan may be ranked as the seventh largest producer of wheat in 2016 if the EU is considered one entity, but it is ranked as the 14th largest exporter, accounting for only a fraction of a percent of the world's wheat exports (FAO). So long as production shortages in Pakistan caused by adverse weather aren't severe enough to create the need for substantial wheat imports to meet domestic demand, Pakistan wheat production should not have much impact on global wheat prices. Nearly all of the wheat Pakistan produces is intended for domestic consumption (Asmat 2015, p. 2).

Two countries that are both major producers and exporters of wheat are Russia and Ukraine. Russia is currently the fourth largest producer of wheat in the world and the second largest exporter as of 2016 (FAO; OEC). Russia has climbed the ranks as a wheat exporter in recent years as the result of a weak ruble and strong dollar, which promotes Russian exports ("Grain and Feed…" 2016). Similarly to crude oil, the Russo-Georgian War had no effect on Russian wheat production, as the conflict did not occur within Russia's borders. Wheat prices increased in the months leading up to the Russo-Georgian War (GEM). In May of 2007, long before the conflict began or markets began to speculate, the price of wheat was $195.72 per ton (GEM). When the conflict began to escalate in April of 2008, the price of wheat had risen to $362.23 per ton, down from a peak of $439.72 in March (GEM). By the end of the Russo-Georgian War in August of 2008, the price of wheat sat at $329.34 (GEM). Clearly the Russo-Georgian War did not impact wheat prices, however a strong La Nina beginning in July of 2007 and ending in April 2008 can explain the dramatic rise in prices leading up to the Russo-Georgian War (USDC). Unlike energy commodities following the Russo-Georgian War, Europe has not attempted to significantly reduce the amount of wheat that it imports from Russia. Between 2006 an 2010, Europe imported an average of 13% of its wheat from Russia each year ("EU Cereals Trade 2011/12" 2012). In the 2015-2016 market year, the EU still imported 13% of its wheat from Russia ("EU Cereals Trade 2015/16…" 2016). It would appear that the EU is not concerned with food security of imports from Russia, likely because it did not attempt to impose sanctions on Russia following the war with Georgia.

Russia, however, in 2014 placed a ban on importing some agricultural and food goods from the EU and other countries that supported sanctions in response to the Russian invasion of Ukraine (Kutlina-Dimitrova 2015, p. 2). It should also be noted that Russia has expanded its exports of wheat to other regions of the world, becoming less dependent on revenue created from Europe purchasing Russian goods. In 2005, 11% of Russian wheat exports went to Europe, and by 2014 only 3.2% of Russian wheat exports were to Europe (OEC). Georgia, however, has not changed its imports of Russian wheat in the long term. In 2005, 88% of Georgia's imported wheat came Russia, and by 2011, that figure had dropped to 37% (OEC). By 2014, though, 87% of Georgia's imported wheat came from Russia again (OEC).

Table 5.2.2

Year	Production (metric tons)		Share of Exports to Europe	
	Russia	Ukraine	Russia	Ukraine
2005	47,697,520	18,699,200	11.0%	36.0%
2006	44,926,880	13,947,300	8.3%	23.0%
2007	49,367,973	13,937,700	9.9%	10.0%
2008	63,765,140	25,885,400	6.3%	28.0%
2009	61,739,750	20,886,400	2.0%	17.0%
2010	41,507,580	16,851,300	2.4%	2.0%
2011	56,239,992	22,323,600	6.5%	29.0%
2012	37,719,640	15,762,600	5.3%	13.0%
2013	52,090,796	22,279,300	4.2%	1.4%
2014	59,711,382	24,113,970	3.2%	6.4%

Sources: FAO; OEC

While Georgia is not a major wheat producer and the Russo-Georgian War would not have had the ability to raise prices outside of small and temporary speculation regarding food exports to the EU from Russia, the conflict in Ukraine could theoretically have a short-term impact on wheat prices. The following analysis will show that the Russia-Ukraine conflict did not and could not significantly impact global wheat prices, despite involving two of the world's largest wheat producers and exporters. As mentioned previously, Russia is the world's fourth largest producer and second largest exporter of wheat (FAO; OEC). Ukraine is the ninth largest producer and sixth largest exporter of wheat (FAO; OEC). In 2013, Ukraine produced 22.279 million tons of wheat (FAO). In 2014, Ukraine increased wheat production to 24.114 million tons, despite Crimea and the two eastern oblasts of Donetsk and Luhansk being occupied by Russian and separatist forces (FAO). There are eleven oblasts in eastern Ukraine, including Crimea, Donetsk and Luhansk ("Ukraine: Estimated Wheat…"). As of 2008 they produced 70% of Ukraine's winter wheat, which account for 95% of Ukraine's total wheat production ("Ukraine: Estimated Wheat…"). As discussed earlier, the EU has not made any effort to reduce its wheat imports from Russia as a result of recent conflicts. Unlike the Russo-Georgian War though, the EU has imposed sanctions on Russia in response to the Russia-Ukraine conflict (Kutlina-Dimitrova 2015, p. 2). During the 2013/2014 market year, Ukraine exported 9.8 million tons of wheat and in the 2014/2015 market year exported 11.3 million tons ("Grain: World Markets…" 2016). During the 2015/2016 market year, Ukraine exported 15.8 million tons of wheat ("Grain: World Markets…" 2016). The data shows that Ukraine was able to increase both its production and exports of wheat despite the conflict with Russia and separatists. Ukraine exports of wheat to Europe have also declined in recent years, as Africa imports more Ukrainian wheat (OEC). Ukrainian export levels to various regions are more volatile than Russian exports, indicating that Ukraine may sell to whomever are willing to buy its wheat at any given time. It would appear that wheat prices increased with the onset of the Russia-Ukraine conflict, rising from $275.53 in January 2014, the month before the conflict began, to a peak of $334.75 in May of 2014 when the conflict was in full swing (GEM). However by September 2014 when the Minsk Protocol was signed, wheat prices had dropped to $243.72 (GEM). The cause of the price increase coinciding with the onset of the conflict was a severe El Nino, which damaged crop production in other regions of the world (USDC). This analysis shows that even during times of conflict, producers within the area of a geopolitical event are capable of not only maintaining but also increasing production of wheat and supplying it to market. This allows the acceptance of the fourth hypothesis for wheat markets. The second hypothesis cannot be tested for wheat markets, as none of the geopolitical events proved to affect prices in the path analysis model.

5.3 Aluminum

Of the three geopolitical events tested in the path analysis and vector error correction models of aluminum, the First and Second Chechen Wars occur within Russia, the second largest producer of aluminum in the world. The third event, the Russo-Georgian War, is important to the discussion of aluminum prices due to the amount of aluminum that Russia supplies to Europe. The First Chechen War proved to effect aluminum prices in the short-term, even if only a miniscule amount, but the second did not prove to have an effect on aluminum prices. The most probable explanation for this is that the First Chechen War, which had a substantial lead up to its initiation, was still a shock to the markets, and consumers likely did not know how it would impact Russian production of aluminum. The answer was that it did not affect Russian production of aluminum.

In the Caucasus region where Chechnya is located, Russia does not have any aluminum mines (USGS). There is one aluminum mine near the boarder of the Caucasus economic region, in the Volga economic region (USGS). In the Caucasus, most of the mines and extraction operations are for lead, uranium, natural gas, salt and zinc (USGS). The rest of Russia's aluminum mines are located in the Urals, central and southern parts of West and East Siberia, and the Northwestern and Northern economic regions that boarder Estonia, Latvia, Finland and the Barents Sea (USGS). Neither the First Chechen War nor the Second Chechen War was geographically close to Russia's aluminum mines. By the Second Chechen War, it can be expected that markets understood the conflict would not threaten Russia's ability to produce and export aluminum, and as a result prices were not affected by the conflict.

In 1994, Russia produced 2.82 million tons of aluminum; in 1995 the figure dropped to 2.722 million and in 1996 when the First Chechen War ended, 2.874 million tons of aluminum were produced (USGS). In 1999 when the Second Chechen War began, 3.146 million tons were produced, and by 2001 the figured had reached 3.3 million tons (USGS). Russian production of aluminum continued to grow through both the Asian financial crisis of 1997 and the recession across Europe and the US in the early 2000's (USGS). In 2007 before the financial crisis began affecting economic activity and aluminum prices, Russia produced 3.955 million tons of aluminum (USGS). In 2008, Russia produced 4.19 million tons, but in 2009 the figure dropped to 3.815 (USGS). This drop in production was not a result of the Russo-Georgian War, but the financial crisis. Russian production began to increase again in 2010, and in 2012 Russia produced 4.024 million tons (USGS). This pattern leading up to, during and after the financial crisis mirrors the global production levels of aluminum. Even though aluminum prices dropped significantly during the financial crisis, as discussed in Part Two, production did not drop by comparable levels (IMF; IAI). The share of Russian aluminum exports to Europe in 1998 was 45% (OEC). In 2014, the figure was 44%, never having dropped below 34% or going over 54% per year, and both of those figures were anomalies, with the median value for the period being 42% and the mean average 42.23% (IAI). Unlike crude oil, Russia has not been able to shift its supply of aluminum exports to Asia, as China already produces massive quantities of aluminum ("China and Trade"). None of the geopolitical events tested in the aluminum path analysis and vector error correction models were able to significantly effect aluminum prices in the long-term because they did not disrupt Russia's ability to produce and transport aluminum to market. This once again allows for the acceptance of the fourth hypothesis, and it can be confirmed that geopolitical events, depending on the situation, are either incapable of significantly affecting production and supply of commodities to market, or other producers will adjust to meet global demand if production is disrupted, whether in the crude oil, wheat or aluminum markets.

To test the second hypothesis within aluminum markets, the same procedure employed to test the Russo-Georgian War in the crude oil market will be used. Only the First Chechen War and Russo-Georgian War proved to affect aluminum prices in the short-term, and so only they will be examined. In the first month of the First Chechen War, the price of a metric ton of aluminum was $1,878.38 (IMF). In the following month of January, prices jumped to $2,059.36, the highest level since the data set begins in December of 1993 (IMF). However, by March of 1995, prices had fallen to $1,799.98, and when the conflict concluded in August of 1996, the price for a metric ton of aluminum was 1,466.79 (IMF). With the results of the path analysis model offering insight on the drivers of aluminum prices, it can be confirmed that the reaction of aluminum prices to the First Chechen War was an overreaction and that prices quickly reverted to pre-event levels while the conflict was still ongoing.

Table 5.3

Year	Russia	
	Production (Millions of Metric Tons)	Share of Exports to Europe
1993	2.820	N/A
1994	2.669	N/A
1995	2.722	42%
1996	2.874	35%
1997	2.906	41%
1998	3.004	45%
1999	3.146	39%
2000	3.245	36%
2001	3.300	39%
2002	3.347	40%
2003	3.478	41%
2004	3.591	42%
2005	3.647	45%
2006	3.717	47%
2007	3.955	54%
2008	4.190	39%
2009	3.815	34%
2010	3.947	46%
2011	3.992	44%
2012	4.024	37%
2013	3.601	46%
2014	N/A	44%

Sources: USGS; OEC

During April of 2008 when the Russo-Georgian War began escalating, the price of aluminum was $2,968.03 (IMF). By July the price had jumped to $3,067.46 as hostilities increased (IMF). However, by August when the conflict reached its peak and then abruptly ended, the price of aluminum fell to $2,762.56 and by December had collapsed to $1,504.42 with the onset of the financial crisis (IMF). It is evident that jumps in aluminum prices following the initiation of the First Chechen War and Russo-Georgian War were overreactions, and that prices quickly receded in the months that followed.

This allows for the definitive confirmation of the second hypothesis, as crude oil prices also reverted to pre-crisis levels following the Russo-Georgian War.

6. Conclusion

The path analysis models from Part Three provide concrete data on how variables within the crude oil, wheat and aluminum markets interact with each other, and ultimately how they influence prices. The models allow us to definitively test the first hypothesis that geopolitical events do not have substantial impacts on physical commodity spot prices. Concerning the price of crude oil, the Russo-Georgian War is the only geopolitical event of the three tested that can be said to have impacted crude oil prices in the short run. Even then, the impact on the price of crude oil was miniscule at best. It was likely caused by speculation that the conflict could lead to a shortage of oil being exported to Europe. The Iraq War and Arab Spring both proved not have had any significant effect on crude oil prices. The Iraq War began during a global increase in crude oil production, and was not capable of sufficiently impacting the supply of crude oil to global markets.

The wheat path analysis model proved that the War in Afghanistan and eventual spillover of hostilities into Pakistan, the Russo-Georgian War, and the Russia-Ukraine conflict did not have the ability to cause an impact on wheat prices. None of them significantly disrupted the production and supply of wheat to markets. The War in Afghanistan and spillover into Pakistan did not have a short-term impact on wheat prices because Pakistan, despite being a major producer of wheat, keeps most of its production for domestic consumption. The Russo-Georgian War did not result in European sanctions against Russia, and Europe has not made any effort to reduce the amount of wheat it imports Russia. The conflict in Ukraine offers a similar story, except that Europe has imposed sanctions on Russia as a result of the conflict.

In the aluminum market, both the First Chechen War and Russo-Georgian War proved to have short-term impacts on wheat prices, although not by substantial amounts. The Second Chechen War did not influence wheat prices in the short-term at all. The First Chechen War likely impacted wheat prices due to market speculators overreacting, something they did not do with the onset of the Second Chechen War. This is supported by the fact the Second Chechen War did not have an impact on prices; market actors understood that conflicts in the Caucasus region did not disrupt the supply of Russian aluminum to international markets. The most plausible cause of the Russo-Georgian

War's short-term impact on aluminum prices is also speculation. The path analysis models' results indicate that we cannot reject the first hypothesis that geopolitical events do not have substantial impacts on commodity prices. They also strongly support the third hypothesis that changes in commodity prices are driven by fundamental supply and demand variables, as well as variables unique to each commodity's own markets, whether it be refinery capacity, stockpile sizes, weather events, or industrial production.

The second hypothesis, that changes in prices caused by geopolitical events quickly revert to pre-event levels is also confirmed, but through a much more simple process than econometric models. Within a month of the end of the Russo-Georgian War, the price of crude oil decreased to levels below what they were when the conflict began. With knowledge that economic activity can severely impact energy and industrial commodity prices, we can conclude that the fall of crude oil prices following the Russo-Georgian War was caused by the global financial crisis. The second hypothesis does not apply to the price of wheat, as the path analysis models show that none of the tested geopolitical events had an impact on wheat prices. When testing the second hypothesis against aluminum prices, the First Chechen War and Russo-Georgian War are the subjects of analysis. Aluminum prices jumped slightly with the onset of the First Chechen War in December of 1994, but long before the conflict ended in 1996 aluminum prices had dropped well below pre-event levels. The same holds true for the Russo-Georgian War, with prices falling well below pre-conflict levels with the onset of the financial crisis.

The third hypothesis, that long-term increases in prices following geopolitical events are caused by supply and demand fundamentals, not geopolitical events, is already strongly supported by the results of the path analysis models. The vector error correction models determined that none of the geopolitical events employed in the models had long-term effects on commodity prices, including the geopolitical events that did have short-term effects on prices. All of the cointegrating equations that contained the non-geopolitical event variables proved to be significant, showing that all of them impacted commodity prices over the span of the data sets. This is more than sufficient to conclude that long-term price rises that may coincide with geopolitical events are not actually caused by the geopolitical events, but other fundamental market variables. The results of the path analysis and vector error correction models mean we cannot reject the third hypothesis.

The fourth hypothesis, that producers within the vicinity of geopolitical events will continue to provide output to markets, and that other producers will adjust production levels if this is not case, is also confirmed. OPEC has proven adept at increasing production levels across member states when one or more member states have their production of crude oil negatively impacted by geopolitical events. OPEC increased production levels as a whole to offset decreases in production in Iraq and Libya, continuing to activate new crude oil wells and rigs during times of conflict. Even with conflicts occurring within their borders, Iraq and Libya were able to continue to produce crude oil. The Russo-Georgian War did not impact Russia's ability to produce crude oil and supply it to market.

The War in Afghanistan spilling over significantly into Pakistan did not prevent Pakistan from continuing to produce wheat, even in the provinces most affected by the conflict. The Russo-Georgian War did not negatively impact Russia's production of wheat because the conflict did not occur on Russian soil. The same holds true for the Russia-Ukraine conflict. Ukraine was able to increase wheat production, even though Donetsk, Luhansk and Crimea, important wheat producing oblasts, were no longer under Ukrainian government control.

All three of the geopolitical events for aluminum involve Russia, and it should come as no surprise that the Chechen Wars and Russo-Georgian War did not affect Russia's production and supply of aluminum to markets. Only one aluminum mine in Russia was located near the Caucasus region where the Chechen Wars occurred. The analysis of production of commodities in regions afflicted by geopolitical events shows that producers in those regions are still able to supply goods to markets. When this isn't the case, as it is in Libya currently, other producers are able to increase production to meet market demand. This shows that the fourth and final hypothesis cannot be rejected.

The models and analysis of geopolitical events allows the acceptance of all four hypotheses, proving that geopolitical conflicts in recent years have not been able to significantly influence the prices of crude oil, wheat and aluminum. The most obvious explanation for geopolitical events inability to affect commodity prices is the globalization of the world economy. The growth of not only production and transportation infrastructure but the increased availability of information regarding markets allows producers and consumers to adjust to changes in markets and continue to meet demand for goods. None of the wars in recent decades that had the potential to affect commodity prices have occurred on truly massive scales as some conflicts earlier in the 20th century did, and it is likely that larger conflicts involving entire continents would have significant and long lasting affects on commodity prices. Data for commodities and the variables that influence them during those time periods does not exist in complete or reliable forms, and so an accurate analysis of their effects on commodity prices is a difficult if not impossible task. Any large scale, continent wide wars that occur in the future might also possibly have significant and long lasting affects on commodity prices, but such an assumption cannot be tested until an event of that magnitude takes place.

Further testing of geopolitical events' effects on commodity prices using different models and methodologies can of course be carried out, however I believe this paper provides a definitive answer to whether or geopolitical events after 1993 have been able to influence commodity prices. An important area that requires more research is how developments in the global economy affect commodity prices and the variables that influence them. This includes advances in technology that provide producers with more efficient and effective methods of production and resistance to shocks, whether those shocks are naturally occurring or manmade.

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World Crude Oil Production	EIA - Energy Information Administration
World Crude Oil Demand	IEA - International Energy Agency
US Dollar Index	Federal Reserve Bank of St. Louis
Federal Funds Rate	Federal Reserve Bank of St. Louis
Crude Oil Refinery Capacity	IEA- International Energy Agency
OPEC Target Allocations	OPEC - Organization of the Petroleum Exporting Countries
World Gross Domestic Product	World Bank
US Crude Oil Refinery Utilization Rate	EIA - Energy Information Administration
Active Oil Rigs	OPEC - Organization of the Petroleum Exporting Countries
Producing Oil Wells	OPEC - Organization of the Petroleum Exporting Countries
Crude Oil Basket Price	IMF - International Monetary Fund
OECD Crude Oil Stockpiles	EIA - Energy Information Administration
Export Shares to Europe of Crude Oil, Wheat and Aluminum	OEC - Observatory of Economic Complexity
Individual Country Crude Oil Production	OPEC - Organization of the Petroleum Exporting Countries
Aluminum Price	IMF - International Monetary Fund
Wheat Price	GEM - Global Economic Monitor Commodities – World Bank
World Industrial Production	World Bank
EL Nino Southern Oscillation	USDC - US Department of Commerce
World Wheat Production	WAOB - World Agricultural Outlook Board
World Wheat Stockpiles	WAOB - World Agricultural Outlook Board
World Wheat Demand	WAOB - World Agricultural Outlook Board
World Aluminum Production	IAI - International Aluminum Institute
World Aluminum Stockpiles	IAI - International Aluminum Institute
Smelting Power Consumption	IAI - International Aluminum Institute
Russian Aluminum Production	USGS - US Geological Survey
Russian Wheat Production	FAO - Food and Agriculture Organization

	of the United Nations
Ukraine Wheat Production	FAO - Food and Agriculture Organization of the United Nations
Pakistan Wheat Production	FAO - Food and Agriculture Organization of the United Nations
Pakistan Provincial Wheat Production	PAIS - Pakistan Agriculture Information System
Wheat Production Rankings	FAO - Food and Agriculture Organization of the United Nations
Aluminum Production Rankings	USGS - US Geological Survey
Wheat Export Rankings	OEC - Observatory of Economic Complexity
Aluminum Export Rankings	OEC - Observatory of Economic Complexity
Pakistan Precipitation	PAIS - Pakistan Agriculture Information System

8. Appendix

8.1 Path Analysis Model Outputs

Oil Path Analysis Output:

Regressions:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE ~				
STOCKS	-3.689	0.438	-8.415	0.000
UTIL	-0.201	0.228	-0.885	0.376
PROD	-1.591	0.673	-2.365	0.018
DEM	9.102	0.634	14.357	0.000
DXY	-1.937	0.107	-18.092	0.000
IRAQ	-0.167	0.066	-2.538	0.011
ARAB	0.036	0.068	0.525	0.599
GEORGIA	0.310	0.073	4.240	0.000
UTIL ~				
PROD	-0.319	0.039	-8.152	0.000
PROD ~				
DEM	0.827	0.012	71.112	0.000
IRAQ	-0.005	0.006	-0.879	0.379
ARAB	-0.014	0.006	-2.160	0.031
GEORGIA	0.001	0.007	0.131	0.896
STOCKS ~				
PROD	-0.238	0.094	-2.542	0.011
DEM	0.641	0.079	8.112	0.000
Variances:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE	0.025	0.002	11.247	0.000
UTIL	0.002	0.000	11.247	0.000
PROD	0.000	0.000	11.247	0.000
STOCKS	0.001	0.000	11.247	0.000
R-Square:				
	Estimate			
PRICE	0.954			
UTIL	0.208			
PROD	0.954			
STOCKS	0.729			

Wheat Path Analysis Output:

Regressions:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE ~				
PROD	-0.821	0.393	-2.090	0.037
DEM	3.016	0.491	6.140	0.000
STOCKS	-0.351	0.085	-4.111	0.000
DXY	-1.942	0.097	-20.112	0.000
AFGHAN	0.009	0.050	0.182	0.856
GEORGIA	0.140	0.077	1.825	0.068
UKRAINE	0.072	0.062	1.163	0.245
PROD ~				
DEM	1.131	0.021	54.861	0.000
EL.NINO	0.019	0.004	4.951	0.000
LA.NINA	-0.009	0.005	-1.956	0.050
AFGHAN	-0.010	0.007	-1.314	0.189
GEORGIA	0.027	0.011	2.442	0.015
UKRAINE	-0.001	0.009	-0.128	0.898
STOCKS ~				
DEM	1.614	0.326	4.949	0.000
PROD	0.723	0.273	2.645	0.008
Variances:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE	0.027	0.002	11.576	0.000
PROD	0.001	0.000	11.576	0.000
STOCKS	0.014	0.001	11.576	0.000
R-Square:				
	Estimate			
PRICE	0.780			
PROD	0.929			
STOCKS	0.719			

Aluminum Path Analysis Output:

Regressions:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE ~				
STOCKS	0.542	0.121	4.476	0.000
POWER	-0.259	0.067	-3.874	0.000
INDUSTRIAL	1.245	0.116	10.765	0.000
DXY	-1.162	0.101	-11.490	0.000
CHECHEN1	0.119	0.054	2.194	0.028
CHECHEN2	0.009	0.051	0.183	0.855
GEORGIA	0.140	0.059	2.382	0.017
PROD ~				
POWER	0.370	0.021	17.284	0.000
INDUSTRIAL	1.190	0.049	24.312	0.000
CHECHEN1	0.010	0.022	0.455	0.649
CHECHEN2	0.037	0.022	1.702	0.089
GEORGIA	0.052	0.024	2.156	0.031
STOCKS ~				
PROD	-0.122	0.040	-3.080	0.002
POWER	-0.246	0.035	-6.974	0.000
Variances:				
	Estimate	Std.Err	Z-value	P(>|z|)
PRICE	0.015	0.001	11.247	0.000
PROD	0.003	0.000	11.247	0.000
STOCKS	0.004	0.000	11.247	0.000
R-Square:				
	Estimate			
PRICE	0.710			
PROD	0.975			
STOCKS	0.809			